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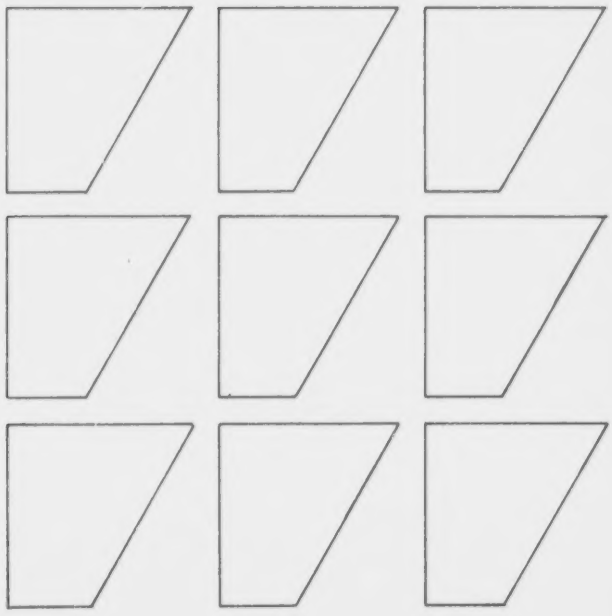
Monograph Series in Finance and Economics

Monograph 1986–3

Expiration Day Effects of Index Options and Futures

By Hans R. Stoll and
Robert E. Whaley



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FINANCE AND ECONOMICS
Monograph 1986–3

Expiration Day Effects of Index Options and Futures

By Hans R. Stoll and
Robert E. Whaley

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Preface

In a letter to the five option exchanges (AMSE, CBOE, NYSE, PACIFIC, PHILA) and the NASD, dated October 16, 1985 the SEC noted its concern about "the price volatility and order imbalances in the securities markets associated with certain arbitrage and related strategies involving trading in index options (and futures on stock indexes) and the underlying component stocks on the last trading day before expiration." Significant attention has also been given in the media to "expiration Friday" effects and program trading. In its letter, the SEC requested an "analysis of the concerns raised by arbitrage and related trading strategies" and suggested that the telescoping of index option position limits or some other modifications might be appropriate. Representatives of the exchanges and the SEC met in mid-November and determined that an independent, comprehensive study of the issues would be appropriate. This study provides a comprehensive empirical analysis of expiration day effects for the period since the inception of index futures and options to February, 1986, the completion date of the study.

We are grateful to the option exchanges for providing logistic support for the study. Joe Levin at the CBOE coordinated efforts to provide us with price and volume data for the stock indices and all their derivative instruments. We wish also to thank the Chicago Board of Trade and Chicago Mercantile Exchange for providing minute-by-minute data for their index futures contracts and the underlying indices for the period since inception of the contracts.

The option exchanges also helped coordinate interviews, held either in person or by phone, with individuals engaged in index arbitrage. The following firms participated: Drexel Burnham, Goldman Sachs, Kidder Peabody, Merrill Lynch, Miller Tabak Hirsch, Morgan Stanley, Salomon Brothers, Shearson Lehman. Three NYSE specialists and certain institutional investors were also interviewed.

Special thanks are due Paul Laux for research assistance beyond the normal call of duty, and helpful discussions with David Emanuel are acknowledged.

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I. Introduction and Overview

Futures and options on broad-based stock indices were first introduced in 1982 and 1983. Since then trading in these instruments has grown dramatically and drawn substantial attention from a somewhat mystified public. The purpose of this study is to examine these instruments with particular attention to the price and volume effects on expiration days.

The study first examines the characteristics and uses of index futures and options and the volume of trading in these instruments. The effectiveness of options and futures as hedging vehicles and risk management tools depends on the maintenance of arbitrage price linkages to the underlying stock indices. These linkages, the arbitrage process and the number and magnitude of arbitrage opportunities are examined in section III. The cash settlement feature of these instruments which is the potential source of expiration day price effects is discussed in Section IV. Section V analyzes open interest in futures and options around expiration days and stock market volume on expiration days. Stock market volume is found to be significantly greater on recent quarterly futures expiration days than on other days. Stock market price effects on futures and options expiration days are analyzed in detail in Section VI for the period since the inception of these contracts. The volatility of stock prices is found to be significantly greater on quarterly expirations when futures contracts expire. Price effects are small when options expire and S&P 500 futures do not, and no price effect is observed for stocks not in the S&P 500 index. Price effects are not observed on all quarterly expirations; and when they occur, are concentrated in a short period of time near the close. The magnitude of expiration day price effects is less than the price effect observed when larger blocks are traded. In section VII the behavior around the expiration day of the spread between the futures price and cash index price is examined to determine if it reflects an expiration day effect. Section VIII shows that predicting expiration day price effects on the basis of past arbitrage opportunities is difficult. Section IX considers the forces that limit adverse stock price effects on expiration day. A summary and conclusions are contained in Section X.

II. Stock Index Futures and Options

A. Characteristics of Stock Index Futures and Options

A futures contract is a binding agreement to buy or to sell an underlying item at a future date at a predetermined price, the futures price. Profits and losses on a futures contract are paid daily. At maturity, short positions still outstanding make delivery to long positions on futures contracts that call for delivery. Index futures contracts call for cash settlement because delivery of a large number of underlying stocks is judged to be difficult and costly. In the case of cash settlement, short and long positions are simply eliminated at the expiration date, since any profits or losses of the longs have already been transferred from the shorts via the daily settlement procedure.

An option conveys the right (not the obligation) to buy or to sell an underlying item at a specified price—the exercise price—within a specific period of time. The right to buy is a call option. The right to sell is a put option. Index options, like futures, specify cash settlement. When an option is exercised, the holder of the option receives the difference between the value of the index at the market close on that day and his exercise price. Index options are American style options that may be exercised before maturity.

The broad based indices and their derivative instruments actively traded at the end of 1985 are listed in Table 1. The underlying indices range in size from the Major Market Index (MMI) which contains 20 blue chip stocks to the Value Line Index which contains 1700 stocks, 80% of which are listed on the New York Stock Exchange and the remainder of which are from the over-the-counter market and the American Stock Exchange. The MMI stocks are weighted by the price of each stock, whereas the Value Line index stocks are approximately equally weighted.[1] The remaining indices weight a stock's price by the market value of the stock in arriving at the index value. The component stocks of the S&P 100, S&P 500, and MMI indices are listed in Tables 2 and 3.

The size of all option contracts is 100 times the index value. The size of futures contracts is typically 500 times the index value, except in the case of the MMI Index and the MMI Maxi Index

[1] A geometric average return is calculated across all stocks each day and added to the preceding day's index value.

TABLE 1

Stock Indices and their Derivative Instruments[1]
as of November 29, 1985

				FUTURES		OPTIONS	
Index	Nr. Stocks	Weighting	11/29/85 Index Value	Exchange[2]	$ Contract Size	Exchange[2]	$ Contract Size
S&P 500	500	Mkt. Value	202.17	CME	$191,000	CBOE	$20,200
S&P 100	100	Mkt. Value	195.63	—	—	CBOE	$19,600
Value Line	1700	Equal Dollar	202.28	KCBT	$101,000	PHILA.	$20,200
NYSE Composite	1500	Mkt. Value	116.55	NYFE	$ 58,300	NYSE	$11,700
						NYSE DBL.	$23,400
Major Mkt.	20	Price	277.88	CBT	$ 27,800	AMEX	$27,800
				CBT Maxi	$ 69,500		
AMEX Mkt. Val.	800	Mkt. Value	242.26	—	—	AMEX[3]	$24,200

[1]Options on futures contracts are available for the S&P 500 futures on the CME, the NYSE Composite futures on the NYFE, and the Value Line futures on the KCBT. These are not listed in the table. Futures and options on OTC stock indices were introduced in late 1985; these are not included in this table.

[2]CME-Chicago Mercantile Exchange; KCBT-Kansas City Board of Trade; NYFE-New York Futures Exchange; CBT-Chicago Board of Trade; CBOE-Chicago Board Options Exchange; PHILA-Philadelphia Exchange; NYSE-New York Stock Exchange; AMEX-American Exchange.

[3]Delisted 1/20/86

TABLE 2

Stocks in the S&P 100 Index

Rank Nov. 14, 1985	Company	Market Value Nov. 14, 1985 (Millions)	% of S&P 100	Cumulative %
1	International Bus. Mach.	$82,850.580	13.55	13.55
2	Exxon Corp.	40,065.460	6.55	20.11
3	General Electric	28,860.405	4.72	24.83
4	American Tel. & Tel.	22,908.573	3.75	28.58
5	General Motors	21,839.742	3.57	32.15
6	Amoco	17,465.605	2.86	35.01
7	Du Pont (E.I.)	15,122.947	2.47	37.48
8	Atlantic Richfield	13,056.550	2.14	39.62
9	Sears, Roebuck & Co.	13,048.416	2.13	41.75
10	Mobil Corp.	12,755.813	2.09	43.84
11	Schlumberger Ltd.	10,522.853	1.72	45.56
12	American Express	10,514.834	1.72	47.28
13	Eastman Kodak	10,427.340	1.71	48.98
14	Coca Cola Co.	10,138.291	1.66	50.64
15	Minn. Min. & Mfg.	9,291.750	1.52	52.16
16	Ford Motor	9,251.200	1.51	53.68
17	Johnson & Johnson	9,078.001	1.49	55.16
18	Merck & Co.	8,711.691	1.43	56.59
19	Bristol-Myers	8,439.799	1.38	57.97
20	Hewlett-Packard	8,399.654	1.37	59.34
21	Wal-Mart Stores	7,997.271	1.31	60.65
22	American Int'l Group	7,415.587	1.21	61.86
23	Dow Chemical	7,363.238	1.20	63.07
24	Boeing Company	7,123.536	1.17	64.23
25	Digital Equipment	6,847.170	1.12	65.35
26	Reynolds (R.J.) Inds.	6,786.024	1.11	66.46
27	McDonald's Corp.	6,200.712	1.01	67.48
28	PepsiCo, Inc.	6,040.386	.99	68.46
29	Citicorp	5,893.842	.96	69.43
30	Southern Co.	5,575.434	.91	70.34
31	Commonwealth Edison	5,500.667	.90	71.24
32	Rockwell Int'l.	5,425.513	.89	72.13
33	Xerox Corp.	5,366.347	.88	73.01
34	United Technologies	5,046.778	.83	73.83
35	Burlington Northern	4,902.72	.80	74.63

TABLE 2 *(continued)*

Stocks in the S&P 100 Index

Rank Nov. 14, 1985	Company	Market Value · Nov. 14, 1985 (Millions)	% of S&P 100	Cumulative %
36	ITT Corp.	4,756.050	.78	75.41
37	Norfolk Southern Corp.	4,594.547	.75	76.16
38	Cigna Corp.	4,445.196	.73	76.89
39	American Elec. Pwr.	4,408.594	.72	77.61
40	RCA Corp.	4,260.750	.70	78.31
41	Raytheon Co.	4,175.523	.68	78.99
42	K mart	4,175.213	.68	79.67
43	Squibb Corp.	3,985.079	.65	80.33
44	Upjohn Co.	3,887.340	.64	80.96
45	Northern Telecom	3,838.340	.63	81.59
46	Occidental Petroleum	3,798.550	.62	82.21
47	Ralston Purina	3,765.452	.62	82.83
48	Weyerhaeuser Co.	3,750.516	.61	83.44
49	Limited, Inc.	3,672.380	.60	84.04
50	NCR Corp.	3,633.493	.59	84.64
51	AMP Inc.	3,518.345	.58	85.21
52	Monsanto Company	3,506.868	.57	85.79
53	American Hospital	3,448.500	.56	86.35
54	Merrill Lynch	3,273.035	.54	86.89
55	Tandy Corp.	3,248.920	.53	87.42
56	Teledyne Inc.	3,205.339	.52	87.94
57	Disney (Walt) Prod.	3,129.711	.51	88.45
58	Honeywell	2,924.878	.48	88.93
59	General Dynamics	2,917.044	.48	89.41
60	Halliburton Co.	2,879.013	.47	89.88
61	Humana Inc.	2,783.953	.46	90.34
62	Sperry Corp.	2,775.532	.45	90.79
63	Alum. Co. of America	2,742.255	.45	91.24
64	Gulf & Western Ind.	2,728.995	.45	91.68
65	Burroughs Corp.	2,656.543	.43	92.12
66	International Paper	2,367.281	.39	92.51
67	Texas Instruments	2,362.534	.39	92.89
68	BankAmerica Corp.	2,318.031	.38	93.27
69	Litton Inds.	2,289.079	.37	93.65

(continued)

TABLE 2 *(continued)*

Stocks in the S&P 100 Index

Rank Nov. 14, 1985	Company	Market Value Nov. 14, 1985 (Millions)	% of S&P 100	Cumulative %
70	Avon Products	2,205.442	.36	94.01
71	Safeway Stores	2,167.128	.35	94.36
72	Warner Communications	2,123.853	.35	94.71
73	Colgate-Palmolive	2,123.813	.35	95.06
74	Champion International	2,112.269	.35	95.40
75	Baxter Travenol Labs	1,868.767	.31	95.71
76	UAL Inc.	1,743.900	.29	95.99
77	Revlon, Inc.	1,624.114	.27	96.26
78	Delta Air Lines	1,593.245	.26	96.52
79	Owens-Illinois	1,558.095	.25	96.77
80	Holiday Corp.	1,153.612	.25	97.02
81	International Flavors & Frag.	1,319.447	.22	97.24
82	Polaroid Corp.	1,184.182	.19	97.43
83	Boise Cascade	1,183.766	.19	97.62
84	Fluor Corp.	1,176.345	.19	97.82
85	Great Western Fin'l.	1,164.002	.19	98.01
86	Homestake Mining	1,129.293	.18	98.19
87	Tektronix, Inc.	1,104.916	.18	98.37
88	NWA Inc.	1,093.490	.18	98.55
89	Int'l Minerals & Chem.	1,059.153	.17	98.73
90	Harris Corp.	1,051.061	.17	98.90
91	National Semiconductor	1,036.066	.17	99.07
92	Williams Cos.	1,025.041	.17	99.23
93	Black & Decker Corp.	1,015.320	.17	99.40
94	Brunswick Corp.	855.698	.14	99.54
95	Bethlehem Steel	764.714	.13	99.67
96	Hughes Tool Co.	698.075	.11	99.78
97	Control Data	688.241	.11	99.89
98	Computer Sciences Corp.	396.598	.06	99.96
99	Skyline Corp.	157.038	.03	99.98
100	Datapoint	104.082	.02	100.00
	Total	**$611,298.992**		

TABLE 3

Stocks in the S&P 500—Alphabetical Listing

AMF Inc.
AMP Inc.
AMR Corp.
ASA Ltd.
Abbott Labs
Acme Cleveland Corp.
Advanced Micro Devices
Aetna Life & Cos.
Ahmenson
Air Products & Chemicals
Alberto-Culver
Albertson's
Alcan Alum.
Allied Corp.
Allied Stores
Allis Chalmers
Alum. Co. Amer.
Amex Inc.
Amerada Hess
Amer. Brands Inc.
Amer. Broadcasting
Amer. Can
Amer. Cyanamid
Amer. Elec. Pwr.
•Amer. Express
Amer. General
Amer. Home Prod.
Amer. Hosp. Supply
Amer. Int'l. Group
Amer. Med. Int'l
Amer. Motors
Amer. Standard
Amer. Stores
•Amer. T. & T.
Ameritech
Amoco
Amated Indus.
Andrew Corp.
Anheuser-Busch
Apple Computer
Archer-Daniels-Midland
Armco Inc.
Armstrong World
ASARCO, Inc.
Assoc. Dry Goods
Atlantic Richfield
Automatic Data Proc.
Avon Prod.

Baker Int'l.
Ball Corp.
Balt. G. & E.
BankAmerica Corp.
Bankers Trust N.Y.
Bank of Boston Corp.
Bard (C R)
Barnett Banks of Fla.
Bassett Furn. Ind.
Baxter Travenol Lab.
Beatrice Foods
Becor Western
Becton, Dickinson
Beker Indus.
Bell Atlantic
Bellsouth
Berns Co.
Beneficial Corp.
Bethlehem Steel
Black & Decker
Boeing Co.
Boise Cascade
Borden, Inc.
Borg-Warner
Briggs & Stratton
Bristol-Myers
Brown & Sharpe Mfg.
Brown-Forman Distillers
Brown Group
Browning Ferris
Brunswick
Burlington Indus.
Burlington Northern
Burroughs Corp.

CBS Inc.
CIGNA Corp.
CNA Financial
CNW Corp.
CPC Int'l
CSX Corp.
Campbell Red Lake
Campbell Soup
Cap Cities Com.
Capital Holding
Carter Hawley Hale
Caterpillar
Celanese
Centex Corp.
Cen. & S. W. Corp.
Champion Int'l. Corp.
Champ Spk. Plug
Chase Manhattan
Chemical N.Y.
Chesebrough
•Chevron
Chi Pneumatic
Chrysler
Chubb Corp.
Church's Fried Chick.
Cinci. Milacron
Citicorp
Clark Equip.
Clorox Co.
Cluett Peabody
Coastal Corp.
•Coca-Cola
Coleco Ind.
Coleman Co.
Colgate-Palm
Columbia Gas
Collins & Arkman
Combus Eng.
Commonwealth Ed
Computer Sciences
Computervision
Con Agra, Inc.
Cons Edison
Cons Freightways
Cons Nat. Gas
Contl Corp.
Control Data
Cooper Industries
Coors (Adolph)
Corning Glass
Cox Communications
Crane Co.
Cray Research
Cross & Trecker
Crown Cork & Seal
Crown Zellerbach
Cullinet Software
Cummins Engine

Dana Corp.
Dart & Kraft, Inc.
Data General
Datapoint
Dayton Hudson
Deere
Delta Airlines
Detroit Edison
Diamond Shamrock
Digital Equip.
Digital Switch
Disney (Walt)
Dome Mines
Dominion Resources
Donnelly (R. R.) & Sons
•Dow Chemical
Dow Jones
Dresser Indus.
Duke Power
•du Pont (E. I.)
Dun & Bradstreet

EG&G
Eastern Gas & Fuel
•Eastman Kodak
Eaton Corp.
Echlin Inc.
Eckerd (Jack)
Emerson Electric
Emery Air Freight
Englehard Corp.
ENSERCH Corp.

•MMI Stocks

TABLE 3 *(continued)*

Ex-Cell-O
●Exxon

FMC Corp.
Fedders Corp.
Federal Express
Federal Paper Bd
Federated Dept. Stores
Fini Corp. of Am.
Firestone
First Chic. Corp.
First Interstate Bancorp.
First Miss. Corp.
First Penn. Corp.
Fleetwood Enter.
FPL Group
Fluor Corp.
Ford Motor
Foster Wheeler
Freehaul Corp.

Gannett Co.
Gen. Cinema
Gen. Dynamics
●Gen. Electric
Gen. Foods
General Instrument
Gen. Mills
●Gen. Motors
Gen. Signal
Genesco
Genuine Parts
Georgia-Pacific
Gerber Prod.
Gillette
Global Marine
Goodrich (B.F.)
Goodyear
Gould, Inc.
Grace & Co.
Grainger (W.W.)
Great A. & P.
Great Northern Nakoosa
Great West'n Fin.
Grumman Corp.
GTE Corp.
Gulf & Western

Halliburton
Handleman Co.
Harcourt Brace Jovanovich
Harris Corp.
Hartmarx Corp.
Hasbro Bradley
Heileman (G.) Brewing
Heinz (H. J.)
Hercules, Inc.
Hershey Foods
Hewlett-Packard
Hilton Hotels
Holiday Inns
Homestake Min.
Honeywell, Inc.
Hospital Corp. of Amer.
Household Intl. Inc.
Houston Nat. Gas
Hughes Tool
Humana

IC Ind.
Inco Ltd.
ITT Corp.
Ideal Basic Indus.
Ingersoll-Rand
Inland Steel
Intel Corp.
Intergraph Corp.
INTERCO, Inc.
InterFirst Corp.
Interlake, Inc.
●Int. Bus. Mach.
Intl. Flavors & Frag.
Intl. Harvester
Intl. Min & Chem.
●Intl. Paper
InterNorth Inc.

Jefferson Pilot
Jim Walker
●Johnson & Johnson
Joy Mfg.

Kaiser Alum.
Kaiser Cement
Kaufman & Broad
Kellogg Co.
Kerr-McGee
Kimberly-Clark
K Mart
Knight-Ridder Newspapers
Kroger

LTV
Leeseway Tr.
Levi Strauss
Libbey-Owens-Ford
Lily (Eli) & Co.
Limited (The) Inc.
Lincoln Metl. Corp.
Litton Ind.
Liz Claiborne, Inc.
Lockheed Corp.
Lone Star Industries
Louisiana Land
Louisiana-Pac
Lowe's Cos.
Lowenstein
Luby's Cafeteria
Lucky Stores

M/A Com Inc.
MCA
MCI Communications
MEI Corp.
MGM/UA Entertainment Co.
Macmillan
Macy (R. H.)
Manufacturers Han.
Marriott Corp.
Martin Marietta
Masco Corp.
Massey-Ferguson
Mattel, Inc.
May Dept. Stores
Maytag
McDermott Int'l.
McDonald's Corp.
McDonnell Douglas
McGraw-Hill
Mead Corp.
Mellon Natl.
Melville Corp.
Mercantile Stores
●Merck
Meredith Corp.
Merrill Lynch
Mesa Pet
Middle S Util.
●Minn. Mining
●Mobil Corp.
Mohesco Corp.
Monarch Mech. Tool
Monsanto Co.
Morgan (J. P.)
Motorola

NCNB Corp.
NCR Corp.
NL Industries
NYNEX
Nabisco Brands
Natt
NL Industries
Nabisco Brands
Natl. Distillers
Natl. Gypsum
Natl. Med. Enter.
Natl. Semiconductor
NYMEX
Natl. Integroup
Newmont Mining
New York Times
Niagara Mo. Power
Norfolk Southern Corp.
North Amer. Coal
North St. Pur.
Northern Telecom

●MMI Stocks

TABLE 3 *(continued)*

NWA Inc.
Norwest Corp.
Northrop
Northwest Ind.
Nozell Corp.
Nucor Corp.

Occidental Petroleum
Ohio Edison
ONEOK Inc.
Outboard Marine
Overnight Transport
Oweno-Corning
Oweno-Ill.

PPG Industries
Paccer Inc.
Pac. G. & E.
Pac. Lighting
Pacific Telesis
Pan Am W. Airw.
Panhandle E. Corp.
Peabody Intl.
Penney(JC)
Pennzoil Co
Peoples Energy
Pepco
Perkin-Elmer
Pfzer Inc.
Phelps Dodge
Phibro Solomon Inc.
Phila. Elec.
●Philip Morris
Phillips Petroleum
Pillsbury Co.
Pitney-Bowes
Pittston Co.
Polaroid
Potlatch Corp.
●Proctor & Gamble
Pub. Ser. E. & G.
Public Serv. of Ind.
Pulte Home
Prime Computer

Quaker Oats

RCA
Ralston Purina
Ramada
Raytheon
Reading Betes
Redman Indus.
Reveo D.S.
Revton
Rexnord Inc.
Reynolds Met.
Reynolds (R.J.)
Rite Aid
Roadway Service
Rockwell Intl.
Rohm & Haas
Roper Corp.
Rowan Cos.
Royal Dutch
Russell Corp.
Ryan Homes
Ryder System

Seleco Corp.
Safeway Stores
St. Paul Co.
Santa Fe Southern Pacific Corp.
Sara Lee
Schering-Plough
Schhamburger Ltd.
Scientific Atlanta
Scott Paper
Seagram Ltd.
Sealed Power Corp.
Searle (G.D.)
●Sears, Roebuck
Shared Medical Systems
Sherman Wing
Shoney's Inc.
Signal Cos.
Singer Co.
Skyline Corp.
SmithKline Beckman
Snap-On-Tools
Sonic Inc.
South Cal. Ed.
Southern Co.
Southland Corp.
Southwestern Bell
Sperry Corp.
Springs Ind.
Square D
Squbb Corp.
Std. Of Ohio
Stanley Works
Sterling Drug
Stevens (JP)
Stone Container
Storer Commut.
Sun Co.
Super Valu Stores

TRW Inc.
Taft Broadcasting
Tandem Corp.
Tandy
Tektrons
Teledyne
Tenneco Inc.
Texaco
Texas Commerce Bankshares
Texas Eastern Corp.
Texas Instruments
Texas Oil & Gas
Texas Utilities
Textron
Thomas & Butts
Tiger Int'l.
Time Inc.
Times Mirror
Tinkon Co.
Toys "R" Us
Tonka Corp.
Transamerica Corp.
Travelers Corp.

UAL Inc.
USF & G Corp.
Unocal Corp.
Undeliver NV
Union Camp
Union Carbide
Union Pac. Corp.
Uniroyal
USG Corp.
U.S. Home Corp.
●U.S. Steel
U.S. Wool
United Technologies
Upjohn Co.
USLIFE Corp.

V.F. Corp.

Wal-Mart Stores
Walgreen Co.
Walker (H.)
Wang Lab.
Warner Com.
Warner Lambert
Waste Management Inc.
Wendy's Int'l.
West-Point Pepperell
Western Co. of North Amer.
Westinghouse Elec.
Westmoreland Coal
Westvaco
Weyerhauser
Whirlpool
White Consolidated
Williams Cos.
Winn-Duane Strs.
Woolworth
Wringley

Xerox

Yellow Freight

Zenith Electronics
Zurn Ind.

●MMI Stocks

TABLE 4

Start Date, Contract Size and Expiration Dates of Index Options and Futures

	S&P 500			NYSE Composite Index			Major Market Index		
Exchange	CME	CBOE	CME	NYFE	NYSE	NYFE	CBT	CBT	AMEX
Contract size	500x Index	100x Index	500x Index	500x Index	100x Index	500x Index	100x Index	250x Index	100x Index
Start	4/21/82	7/1/83	1/28/83	5/6/82	9/23/83	1/28/83	7/23/84	8/8/85	4/29/83
Expirations									
1982									
June	17			29					
July									
August									
September	16			29					
October									
November									
December	16			30					
1983									
January									
February									
March	17		17	30		30			
April									
May									
June	16		16	29		29			17
July									
August									
September	15	16	15	29		29			16
October									

November					16				
December	15	16	15	29	16	29			16
1984									
January					20				20
February					17				17
March	15	16	15	29	16	29			16
April					19				19
May					18				18
June	15	15	15	28	15	28			15
July					20				20
August					17		17		17
September	21	21	21	27	21	27	21		21
October					19		19		19
November					16		16		16
December	21	21	21	21	21	21	21		21
1985									
January					16		16		16
February					15		15		15
March	15	15	15	15	15	15	15		15
April					19		19		19
May					17		17		17
June	21	21	15	21	21	21	21		21
July					19		19		19
August					16		16	16	16
September	20	20	20	20	20	20	20	20	20
October					18		18	18	18
November					15		15	15	15
December	20	20	20	20	20	20	20	20	20

(continued)

TABLE 4 *(continued)*

	S&P 100	Value Line Index		Mkt. Val
	Options	Futures	Options	Options
Exchange	CBOE	KC	Phil	AMEX
Contract size	100x Index	500x Index	100x Index	100x Index
Start	3/11/83	2/24/82	1/11/85	7/8/83
Expirations		3/31/82		
1982				
June		30		
July				
August				
September		30		
October				
November				
December		31		
1983				
January				
February				
March		31		
April				
May				
June	17	30		
July				
August				
September	16	30		16
October				
November				
December	16	30		16
1984				
January	20			20
February	17			17
March	16	30		16
April	19			19
May	18			18
June	15	29		15
July	20			20
August	17			17
September	21	28		21
October	19			19

(continued)

TABLE 4 *(continued)*

	S&P 100	Value Line Index		Mkt. Val
	Options	Futures	Options	Options
Exchange	CBOE	KC	Phil	AMEX
Contract size	100x Index	500x Index	100x Index	100x Index
Start	3/11/83	2/24/82	1/11/85	7/8/83
November	16			16
December	21	31		21
1985				
January	18			18
February	15		15	15
March	15	29	15	15
April	19		19	19
May	17		17	17
June	21	28	21	21
July	19		19	19
August	16		16	16
September	20	30	20	20
October	18		18	18
November	15		15	15
December	20	20	20	20

for which the sizes are 100 and 250 times the underlying index, respectively.

Futures options, options written on index futures contracts, rather than on the underlying index itself, also exist in the case of the S&P 500 Index and the NYSE Composite Index. These are not examined in this study.

The start of trading and the expiration dates since inception of index futures and options are given in Table 4.

B. Uses of Index Options and Futures

The widespread trading of options and futures on stock indices and on a large range of other underlying items attests to the uses of options and futures as hedging vehicles, as cost saving means of adjusting positions in underlying assets, and as cost effective means of registering opinions about the value of underlying assets. While options and futures have been viewed with a certain amount of suspicion by the general public, careful analysis of these instruments shows that they yield benefits not only to private users but also to society as a

whole. The recent joint report to Congress by the Federal Reserve Board, Commodity Futures Trading Commission and Securities and Exchange Commission, *A Study of the Effects on the Economy of Trading in Futures and Options* (December 1984), examines the uses of index futures and options by institutional investors, professional traders and individuals. The uses of index futures or options are also examined in Figlewski (1984a), Moriarity, Phillips and Tosini (1981), Silver (1985), Stoll and Whaley (1985), and Tosini and Moriarity (1982).

Stock index futures and options can serve to modify the risk characteristics of a portfolio. For example, selling index futures against a long position in relatively few stocks allows an investor to avoid (sell off) "market" risk inherent in these stocks while concentrating on assuming the company specific risk. Thus, investors that desire to focus analysis on forecasting the prospects for a particular company rather than for the market as a whole can use index futures to assume only those risks with which they are comfortable. The use of index options can serve to modify the risk of a portfolio in a way different from futures. For example, one can be insured against market price declines by purchasing a put. On the other hand one can forego the benefits of a market increase while assuming the risks associated with a market decline by writing calls, something one may want to for a sufficient premium.

Index futures and options can be helpful to underwriters and market makers. For example, buying put options can serve to hedge an underwriter who has granted an option to a corporation or institution to sell stock at a fixed price. Similarly market makers that have acquired stock in the process of making markets can hedge an inventory position by selling futures or by buying puts.

Index futures and options are useful also because they can reduce the costs associated with trading the underlying portfolio stocks as when a portfolio is rebalanced or when additional funds are invested. For example, an institution interested in selling (or buying) a large portfolio of stocks quickly might find it advantageous to sell (or buy) futures rather than to trade the individual stocks. This is because transaction costs are considerably lower in the futures market than in the stock market. The (one-way) commission cost of selling 100 S&P 500 futures contracts is about $1250.00 while the (one-way) cost of selling the corresponding amount of underlying stocks ($10,000,000), assuming a rate of $0.07 per share, is about $17,500. Subsequently, the individual stocks may be sold so as to miminize market impact, and the short futures position can be covered. Frequently a brokerage firm will agree to purchase the portfolio of stocks from the institution (or

sell stock to the institution) and will enter the futures or options market to hedge its obligation.

Institutions engaged in temporarily changing the proportion of stocks in a portfolio, can do so at much lower cost by using futures and options than by trading the underlying stocks. For example, an institution holding a diversified portfolio of stocks and fearing a stock market decline, can sell index futures against all or part of its portfolio, thereby offsetting any stock market losses by gains on the short futures position. When the stock market has bottomed out, the short futures position can be covered; and the more costly trading in stocks is avoided.

"Program trading"—the purchase or sale of portfolios of stocks—predates index futures and options since institutions have in the past had the desire to rebalance portfolios or to time the market. The growth of index funds that need to invest cash inflows in a broad mix of stocks has also contributed to program trading. Index futures and options have, however, facilitated the growth of program trading by reducing its costs. At the same time stock market transactions technology has improved so as to facilitate the speedy execution of program trades. This study does not deal with the effects of program trading except insofar as program trading occurs on expiration days.

The FRB/CFTC/SEC Study (1985) concludes that, "very little purely speculative activity is engaged in by institutional investors in new options and futures products." (p. 13, Appendix IV-A) Institutions use options and futures to hedge risk or to manage more efficiently their basic investment strategy. According to the FRB/CFTC/SEC Study, individual non-commercial traders tend to take speculative positions in index futures and options. In a sample of 796 individuals trading stock index futures or options, 86-96 percent indicated speculation rather than hedging as their investment objective. That large commercials use futures to hedge while individuals provide speculative capital is typical of many futures and options markets.

From the perspective of society, index options and futures are useful because they enable risk to be transferred to those individuals that are most able to assume it and because they can reduce the transaction cost of accomplishing various investment objectives as compared with the cost of trading in the stock market. A frequently expressed concern is that options and futures markets will detract from the liquidity of the underlying markets and thereby adversely affect the prices in underlying markets and the capital formation process itself. The FRB/CFTC/SEC Study concludes that liquidity in underlying markets tends to be enhanced (page I-2). Somewhat paradoxically, the concerns with respect to index futures and options are not that options

and futures detract from trading in stocks but that trading in stocks is excessive at certain points of time—particularly expiration days.

C. Volume and Open Interest in Stock Index Futures and Options

Volume data on stock index futures and options are contained in Tables 5 and 6. Open interest data for November 29, 1985 are in Table 7. Futures on the S&P 500 are the most actively traded of index futures, with average monthly volume in terms of the contract size exceeding the monthly volume on the New York Stock Exchange. Options on the S&P 100 are the most actively traded of index options. Again, combined put and call monthly volume in terms of the claim on the underlying stocks exceeds monthly volume on the New York Stock Exchange. The high volume of index futures and options reflects, in part, the short term trading activity of market makers and floor traders in these markets. For example, in the options market, approximately 30 percent of the volume is for the account of customers and in excess of 60 percent of the volume is for the account of market makers. Short term floor traders on futures markets are also said to account for more than 50 percent of the index futures volume on futures exchanges.[2]

Since floor traders tend not to carry positions overnight, open interest in futures and options—the number of contracts outstanding on any day—is modest relative to the volume of trading, particularly in futures contracts. For example, on November 29, 1985, open interest in all index futures contracts amounted to $9.8 billion, which compares with index futures volume on that day of $6.59 billion. Open interest in index puts and calls combined amounted to $31.8 billion, which compares with the combined index options volume for the day of $6.83 billion.

On the stock exchange, by contrast, the volume of trading in stocks averages only about 5.6 percent of the total value of all shares outstanding. Open interest in index futures and options is therefore also modest when compared with the total value of all shares outstanding. Indeed open interest in all index futures contracts combined—$9.799 billion on November 29, 1985—is less than the equity holdings of a number of institutional investors and on November 29, 1985 amounted to about 5.5% of the value of all NYSE stocks.[3] When viewed in terms of open interest, activity in futures and options is not large. Indeed one might predict a considerable increase in the open interest in futures and

[2]See "The Options Clearing Corporation Statistical Reports, Non-Equity and Index Options" monthly for options data. Precise data on the proportion of futures market trading for the account of customers and for the account of professional trades on the floor is not available.

[3]As of December 31, 1984, 11 institutions each managed equity funds in excess of $10,00 million.

options as institutional investors become more familiar with index products.

Additional data on the composition of open interest is available for index futures contracts from the "Commitments of Traders" data compiled by the CFTC. Table 8 contains data for November 29, 1985. Relatively few traders—58 in the S&P 500 futures—hold positions in excess of the reporting level, and large trader positions tend to account for about 50% to 60% of the open interest. Large traders are primarily commercials, that is, they have a commercial interest in the underlying cash commodity, as an institutional investor or a broker-dealer firm. Data on position limits in index futures and options are contained in Table 9.

TABLE 5

Index Futures
Average Monthly Volume
Year Ending September 30, 1985

	Nr. of Contracts	Approximate Dollar Value ($ Million)
Index Futures Contracts		
S&P 500	1,193,584	106,229
Major Market	233,319	5,763
Value Line	88,357	7,864
NYSE Composite	242,358	12,360
MMI Maxi[1]	66,257	4,091
Total Index Futures Per Month		136,307
NYSE Round Lot Volume Per Month		72,850

Source: CFTC Annual Report, 1985; NYSE.
[1]Started trading 8/8/85

TABLE 6

Index Options
Average Monthly Volume
Calendar 1985

	CALLS		PUTS	
	Nr. of Contracts	Approximate Value ($ Million)	Nr. of Contracts	Approximate Value ($ Million)
Option Contracts				
CBOE (S&P 100)	4,650,460	81,383	2,918,046	51,066
AMEX (MMI, MMI MAXI)	597,563	14,760	438,928	10,842
NYSE (NYSE COMP, DBL)	222,055	2,265	133,216	1,359
Phila (Val. Line)	123,270	2,194	70,148	1,249
Total Options, Per Month		100,602		64,516
NYSE Round Lot Volume Per Month			580,000	

Source: Option Clearing Corporation Reports.

TABLE 7

Index Options and Futures
Open Interest on November 29, 1985

	FUTURES		OPTIONS			
			CALLS		PUTS	
	Number of Contracts	$ Value Underlying ($ million)	Number of Contracts	$ Value Underlying ($ million)	Number of Contracts	$ Value Underlying ($ million)
S&P 500	74,909	7,572				
S&P 100			526,150	10,313	720,326	14,118
Value Line	11,926	1,206	21,251	430	25,426	514
NYSE Composite	8,131	474	16,247	189	49,825	581
NYSE Composite DBL.			17,915	418	24,669	575
Major Mkt.	1,765	49	73,378	2,040	93,586	2,602
Major Mkt. MAXI	7,169	498				
Total		9,799		13,390		18,390

Source: Wall Street Journal.

TABLE 8

Index Futures
Size and Composition of the Open Interest
By Contract, November 29, 1985

	S&P 500 (CME)	NYSE COMP (NYFE)	MMI (CBT)	Maxi MMI (CBT)	Val. Line (KCBT)
Open Interest (All Series)					
$ Value of Open Interest ($ Million)	7,572	47	49	498	1,206
Large Traders:					
Reporting Level (Number of Contracts)	300	100	100	25	25
Number Reporting	58	23	8	30	63
% Open Interest Held By:					
Large Commercial[1]					
Long	53.8%	25.0%	49.7%	30.8%	17.9%
Short	40.1%	10.1%	46.8%	73.6%	20.9%
Large Non-Commercial[1]					
Long	7.1%	35.2%	31.2%	51.7%	21.9%
Short	15.9%	41.0%	7.6%	19.2%	33.3%
Non-Reporting					
Long	39.2%	39.5%	19.2%	17.5%	60.2%
Short	44.0%	49.0%	45.6%	7.2%	45.9%

Source: CFTC, Commitments of Traders.

[1]A commercial is anyone with a position in the index stock or anyone dealing in the index stocks.

TABLE 9

Position Limits
Stock Index Futures and Options Contracts

Index	Futures Limits[1]		Option Limits[2]	
	Contracts	Value[3] ($ million)	Contracts	Value[3] ($ million)
S&P 500	5,000	500	15,000	300
S&P 100			15,000	294
Value Line	5,000	500		
NYSE Composite	5,000	292	25,000	300
NYSE Comp. Double			12,500	300
Major Market	20,000	556	10,000	278

Source: Federal Reserve Board, CFTC and SEC, *A Study of the Effects on the Economy of Trading in Futures and Options*, December, 1984.

[1]Position limits in futures contracts apply to the net speculative position in all futures contract series combined. Hedgers, who deal in the underlying index are not subject to position limits. Position limits do not apply in the spot month in the case of index futures or other products that cash settle. The position limit applies to the aggregate of all related accounts.

[2]Position limits in option contracts apply to the sum of all option series on the same side of the market in each option class. There are no exemptions to limits for hedged positions. The limit applies to the aggregate of all related accounts. For NYSE options, the limit is specified in dollar terms at $300 million, and the number of contracts depends on the current index value. For the other options the limit is specified in contracts.

[3]Dollar value based on November, 1985 index values.

III. Arbitrage Linkages

Index futures and options provide benefits to their users only if market participants are confident that these instruments are linked to the underlying indices. Arbitrage maintains these links; and, through arbitrage, the liquidity of the underlying market is enhanced. A lack of confidence in this linkage reduces greatly the hedging value of index futures and options.

A. Arbitrage of Futures Versus Cash Index

1. Theory

The equilibrium relationship between the futures price and the underlying index price is given by the cost of carry relationship:

$$\frac{365}{m}\left(\frac{F\text{-}S}{S}\right) = r\text{-}d, \qquad (1)$$

where

F = index futures price.
S = cash index price. We call (F-S)/S the basis.
r = annualized interest rate of borrowing funds over the time period remaining until the maturity of the futures contract.
d = annualized divided yield = dividend payments to be received by holders of the index stocks in the time remaining until maturity of the futures contract, expressed as a proportion of the cash value of the index and annualized.
m = the number of days until maturity of the futures contract.

In other words, (1) says that the annualized basis equals the annualized net cost of carrying the index. The net cost of carrying the index is the interest rate less the dividend yield on the index stocks.

If the basis exceeds the net cost of carrying the index by more than transaction costs, an arbitrager buys the index by buying some or all of the stocks in the index and sells futures. This is called a long arbitrage. The opportunity cost of funds tied up in the long position in stocks is r, which is offset to some degree by the dividend yield, d, on the stocks. If the position is held to maturity and if there is

convergence so that F = S at expiration, the arbitrager collects an annualized net return of

$$\left(\frac{F\text{-}S}{S} - T\right)\frac{365}{m} - (r\text{-}d)$$

where T is transaction costs expressed as a fraction of the index. This type of arbitrage is attractive to brokerage firms and institutional investors with ready access to funds if a return sufficiently in excess of the Treasury bill return can be earned.

If the basis is less than the net cost of carrying the index by enough to outweigh transaction costs, an arbitrager sells short the stocks in the index and buys index futures—a short arbitrage. The arbitrager earns interest on the proceeds of the short sales and pays dividends on stocks he holds short if such stocks go ex-dividend during the period of the arbitrage. If the position is held to maturity, the arbitrager earns an annualized return of

$$-\left(\frac{F\text{-}S}{S} + T\right)\frac{365}{m} + (r\text{-}d).$$

In the presence of transaction costs (1) is replaced by

$$(r\text{-}d) - T\,\frac{365}{m} \leq \left(\frac{F\text{-}S}{S}\right)\frac{365}{m} \leq (r\text{-}d) + T\,\frac{365}{m}, \qquad (2)$$

that is, the annualized basis must be less than or equal to the annualized net cost of carrying a long position plus the annualized transaction cost and must be greater than or equal to the annualized net carrying cost less the annualized transaction cost, or an arbitrage opportunity exists.

2. Futures Arbitrage in Practice

a. Long Arbitrage

In practice, the long arbitrage (that is, long stocks in the index) is complex since the arbitrager must buy the component stocks of the index. The index itself is not traded. While it is not difficult to buy the 20 stocks in the Major Market Index, buying 500 stocks in the S&P 500 index is cumbersome. Nevertheless, the technology for buying portfolios of stocks—program trading—has developed to the degree that all 500 stocks can be purchased if desired. More typically, a large basket of stocks—on the order of 200 stocks—is purchased to

represent the index. Brokers have developed procedures for dividing the component stocks among floor brokers thereby making it possible, upon command, quickly to execute a program. A number of factors must be considered when establishing an arbitrage position.

Transaction Costs. Transaction costs include (a) commissions to buy and sell the stocks in the index, (b) commissions to sell and buy futures contracts, (c) the market impact of buying stocks at the ask price and selling stocks at the bid price. These latter costs can be substantial and may be difficult to predict. An arbitrage opportunity on the basis of last transaction prices may disappear by the time brokers execute transactions in each of the individual stocks. This is particularly so if several arbitragers are acting on the same arbitrage opportunity. Market practitioners estimate total proportional roundtrip transaction costs from all these factors to be on the order of 0.5 percent to .75 percent of the underlying value. For example, the commission to trade 100 S&P 500 futures contracts is approximately $1250. The commission to trade the corresponding value of underlying stocks (100 x value of S&P 500 futures contract = $10,000,000), assuming a commission rate of $0.07 per share is approximately $17,500. Assuming a bid-ask spread of one index point, the one-way market impact associated with buying or selling the underlying stocks is $25,000. The one-way market impact associated with trading the 100 futures contracts is estimated to be $1250. If the arbitrage position is held to maturity, market impact costs arise only when the position is established, not when it is unwound. As a result the roundtrip transaction cost is two commissions plus one market impact cost, or $61,250—0.6125 percent of the market value of the underlying stocks. An opportunity to unwind before expiration would be taken if the incremental profit exceeded the market impact cost of the unwinding. Transaction costs are likely to be lower than 0.6125 percent for brokerage firms trading their own accounts.

Dividend Yield Risk. The dividend yield specified in (2) is an anticipated dividend yield. If dividends are cut, the long arbitragers' returns are reduced.

Tracking Risk. If a basket of stocks rather than the entire index is purchased, the arbitrager may take a loss relative to the futures market position since the futures price does not necessarily converge to the basket price.

Sophisticated arbitragers have the facility to assess and monitor these three factors on a continuous basis. For example, in determining whether to undertake an arbitrage, sophisticated computer services exist that determine the value of the index based on the bid prices of the component stocks or the ask prices of the component

stocks thereby estimating the market impact cost. The dividend yield on the index or any basket of stocks is readily available and is based on known past declaration dates and amounts. These computer services are widely available, and therefore an arbitrage opportunity produces a quick reaction. Once an arbitrage position is established, the position is monitored and the tracking risk is evaluated continually.

Futures arbitrage requires a minimum dollar position in the underlying index stocks so as to minimize transaction costs as a percentage of the position. In practice, arbitrage in the Major Market Index involves a stock program of about $3 million. The S&P 500 Index can be arbitraged using a basket of stocks amounting to $10 million, but arbitrage using all 500 stocks is said to require about $25 million. Of course, once an arbitrage opportunity is identified, market participants want to assemble as large a program as possible.

Arbitrage is carried out by those participants that incur the lowest transaction costs and have the lowest opportunity cost of funds. Brokerage firms trading for their own accounts face the lowest transaction costs and are important arbitragers for this reason. Two factors can limit brokerage firms' arbitrage. First the availability of brokerage firms' capital can be constrained by net capital requirements and the manner in which "haircut" provisions are applied to positions in futures and stocks as well as the manner in which margin requirements are applied to arbitrage positions. (Since arbitrage positions are riskless, or nearly riskless, both margin requirements and haircut provisions ought in principal to be minimal.) Second, brokerage firms tend to be net borrowers of funds and may have uses for funds that are more profitable than index arbitrage. The fact that brokerage firms have marketed arbitrage programs to their customers indicates that opportunities in excess of street capital have been available.[4]

Natural long arbitragers are institutional investors that invest in low risk, short term debt instruments. Such investors have ready access to cash and view as their opportunity cost of funds the yield on short term investments, not the cost of borrowing funds. Long index arbitrage is attractive for such institutions whenever a net return in excess of that on CDs or Treasury bills can be guaranteed. That return can be significantly less than the return required by an arbitrager who must borrow new funds for the arbitrage.

Aside from the direct arbitrage discussed, other methods of arbitraging an unwarranted basis exist. For example, institutional investors holding a stock position may find it desirable to sell futures against that position to lock in a high known return should the futures

[4]See for example Goldman Sachs, "The Handbook of Stock Index Arbitrage" and Morgan Stanley, "Trading Strategies for Stock Index Products."

price become large relative to the spot price. This strategy, however, denies the institution any gains from increases in the stock market.

b. Short Arbitrage

In practice, the short arbitrage position poses a number of difficulties in addition to those posed by the long arbitrage position. The most serious of these is the short-sale rule. An arbitrager attempting to sell short a basket of 200 stocks must wait for an up-tick in each of the 200 stocks. As a result the arbitrager may be unable to establish a short position that properly represents the index. This difficulty is less in the Major Market Index which contains only 20 stocks, but it is quite severe in the S&P 500 or the New York Stock Exchange Composite Index. Some difficulties may also arise in borrowing the stocks for the short sale, but facilities for borrowing shares appear to be well developed.

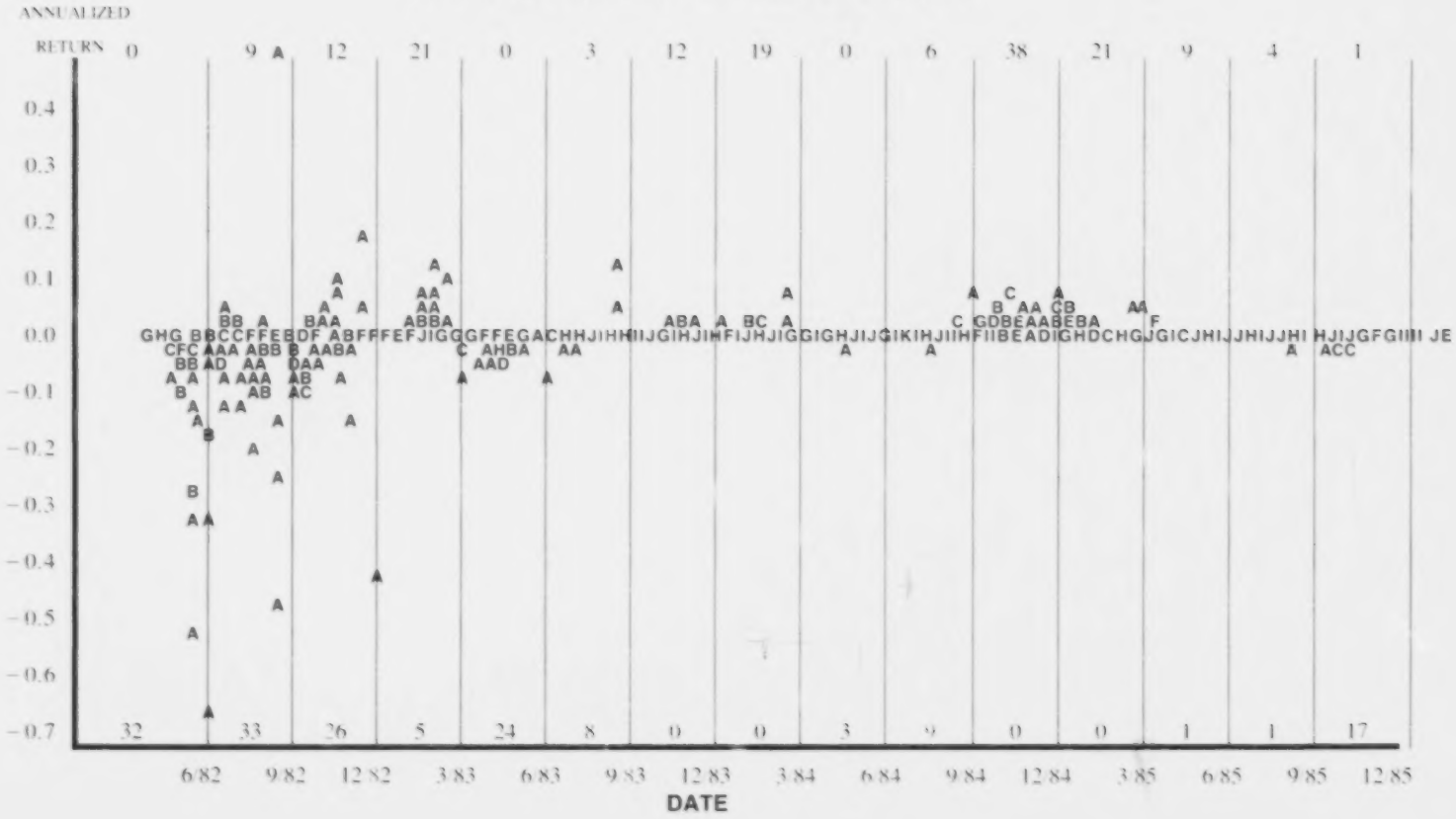
Because of short selling impediments, arbitrage of a basis that is too low frequently takes the form of stock replacement strategies. Institutional investors that already own the index stocks sell these stocks, put the proceeds in short term debt instruments and replace the stocks with the purchase of futures contracts. The new position has the same economic payoff as the initial position but at lower cost. Sometimes professional arbitragers that do not hold index stocks may establish a long arbitrage position (that is, long index stocks, short futures) at no profit in order to be prepared to sell those stocks from a long position to take advantage of a short arbitrage opportunity. In other words, they may establish a long arbitrage position at no profit in anticipation that they may be able to unwind it before maturity at a profit.

3. Arbitrage Opportunities in Index Futures

Arbitrage opportunities in index futures have attracted a great deal of interest not only among practitioners but also among academic researchers. Papers by Cornell and French (1983), Figlewski, (1984b), and Peters (1985) have, for example, found arbitrage opportunities during the early life of futures contracts and have offered explanations for the existence of these opportunities. Arbitrage opportinities have declined over time as markets have become familiar with the new index futures contracts, and conversations with arbitragers confirm this trend. Figure 1 plots arbitrage opportunities in the nearby S&P 500 futures based on equation 2. A proportional transaction cost of 0.5 percent and a dividend yield of 4 percent per year are assumed. The interest rate in the analysis is the three month certificate of deposit

FIGURE 1

S&P 500 Futures Arbitrage Opportunities Based on Daily Closing Prices
(A = 1 Observation, B = 2 Observation, etc.)



rate. Daily closing prices for futures and the underlying index are used in this analysis. An opportunity for long arbitrate is plotted as a positive annualized return and an opportunity for short arbitrage is plotted as a negative annualized return. The vertical lines in the table indicate the expiration dates, and the numbers across the bottom and the top of the chart indicate the number of short and long arbitrage opportunities prior to each expiration date. When no arbitrage opportunity in excess of transaction costs is found, a zero is plotted. Since the dividend yield varies depending on which stocks are due to pay dividends, some of the arbitrage opportunities may be overstated and some may not be shown. However, the trend to a decline in the number of arbitrage opportunities is evident in the figure.

B. Arbitrage of Options Versus Cash Index

1. Theory

The arbitrage linkages between options and the underlying index are more complicated than in the case of futures because options have an early exercise privilege. Stoll (1969) first specified the put-call parity condition for individual stocks. Stoll and Whaley (1985b) specify in detail the arbitrage linkages between new options and underlying instruments. Whaley (1985) examines mispricing of S&P 500 futures options.

In the absence of an early exercise privilege a slightly simplified version of the put-call parity relation between options and the underlying index is[5]

$$\frac{365}{m}\left(\frac{C\text{-}P}{S} - \frac{S\text{-}X}{S}\right) = r\text{-}d, \qquad (3)$$

where

C = the call option price.
P = the put option price.
X = the exercise price of the put and the call option.

The similarity between (1) and (3) should be noted.

If the difference between the call and put price, adjusted for the in-the-money amount of the call, exceeds the net cost of carrying the underlying index stocks (r-d), an arbitrager would buy puts and sell calls with the same exercise price (a synthetic short position) and would buy the underlying stocks. The purchase of the

[5]Ignored in the equation is that one should take the present value of (S-X), the dividend yield, and r in order to put these quantities on the same basis as C-P, which is a current payment. Relative to transaction costs, this omission is not critical, especially in view of the fact that the active option series are short term of less than one month.

underlying index stocks is financed by new funds and by the cash generated if $C > P$. The opportunity cost of funds is offset by the dividends paid on the stocks owned. If the call price is too low relative to the put price, the arbitrage is in the opposite direction: sell puts, buy calls, (synthetic long) and short the index stocks.

Because American options may be exercised before maturity, the long arbitrager (who sells calls) cannot guarantee that dividends will be received since the dividend paying stocks may be called away before maturity. This is quite likely since a dividend payment is accompanied by a stock price decline and since call options are not protected against such price declines. On the other hand, the short arbitrager (who has sold puts) knows that dividends will have to be paid on the short position. This asymmetry, along with the existence of transaction costs results in the following arbitrage bands, which are stated in annualized terms:

$$(r\text{-}d) - T\,\frac{365}{m} \leq \left(\frac{C\text{-}P}{S} - \frac{S\text{-}X}{S}\right)\frac{365}{m} \leq r + T\,\frac{365}{m} \qquad (4)$$

If the upper boundary is violated, a long arbitrage position is established. If the lower boundary is violated, a short arbitrage position is established.

2. Options Arbitrage in Practice

In practice, the long option arbitrager must deal with many of the same complications faced in futures arbitrage—buying a portfolio of stocks quickly, transaction costs, dividend uncertainty and tracking risk. Indices underlying the popular option contracts—the S&P 100 and the Major Market Index—contain fewer stocks than the indices underlying the most active futures contracts—the S&P 500. As a result, it is more readily possible to match the underlying index and reduce the tracking error in options.

On the other hand, an options arbitrager faces a number of additional uncertainties arising out of the early exercise possibility. A long arbitrager who has sold calls faces the danger that the call will be exercised against him before maturity; and, by the time new calls are sold, the position will have moved against the arbitrager. That delay is quite real since calls may be exercised at the market close, in which case one must wait until the next morning to re-establish the position. In index options, which cash settle, the call buyer has an incentive to exercise if a stock market decline is occurring that has not yet been fully reflected in the index. The index tends to lag the market,

since not all stocks in the index trade simultaneously. By exercising a call option, the call owner may receive a profit in excess of what the profit would be if the index instantaneously reflected market conditions.[6]

As in the case of futures, short arbitrage in options—buying calls and selling puts against a short position in index stocks—is made difficult by the short-sale rule.

Conversations with market participants suggest that arbitrage in index options is less frequent and of lesser magnitude than arbitrage in index futures. This may be due in part to the early exercise feature of options. In addition options trading can take a variety of forms that may make direct long or short arbitrage undesirable or unnecessary. For example, when calls are overpriced, institutional investors can increase their option writing programs, without establishing a full arbitrage position. Similarly, if puts are underpriced, institutional investors may increase their purchase of protective puts.

3. Arbitrage Opportunities in Index Options

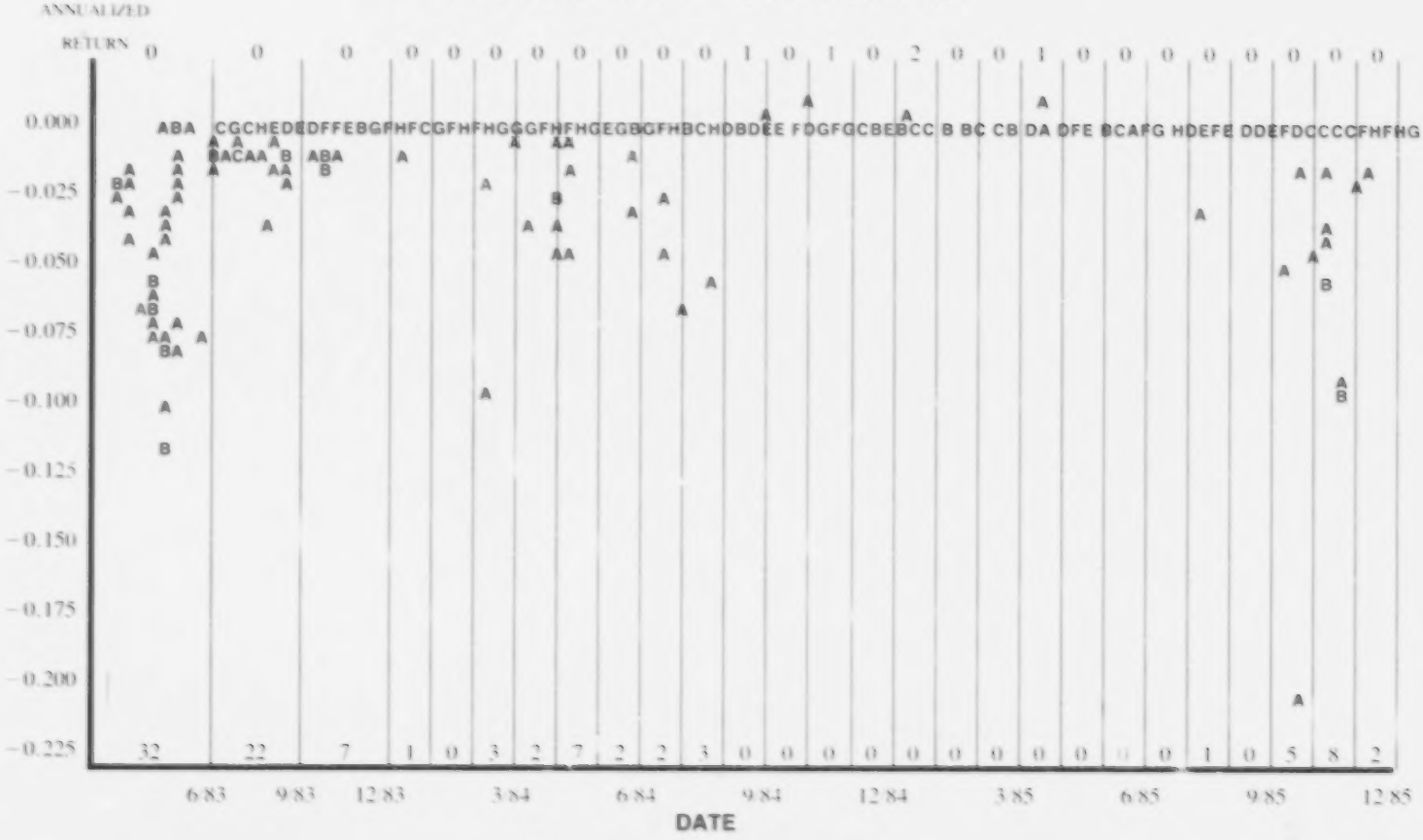
As in the case of index futures, arbitrage opportunities have existed in index options. Evnine and Rudd (1985) examined options prices during the period June and July of 1984 and found frequent mispricing of options. These conclusions are in part reflected in Figure 2, which plots annualized value of arbitrage opportunities based on daily closing prices. Arbitrage opportunities are calculated on the basis of (4) for the most actively traded nearby S&P 100 index call option (and the corresponding put). A proportional transaction cost of 0.5 percent and a dividend yield of 4 percent per year are assumed. If the upper bound in (4) is violated, the implied annualized return is plotted as a positive value. Such a violation, which implies calls are overpriced relative to puts, leads arbitragers to take a long position in index stocks. If the lower bound in (4) is violated, the implied annualized returns is plotted as a negative value. Such a violation which implies puts are overpriced relative to calls, leads arbitragers to take a short position in index stocks. In contrast to futures, most violations in Figure 2 are of the lower bound. The few upper bound violations may result from the fact that (4) assumes the long arbitrager will not receive the dividend. The total number of arbitrage opportunities have been less in options than in futures. As in futures the number of arbitrage opportunities has declined over time.

[6]No problem exists in a delivery market because the exercise of a call results in delivery of stocks which must then be disposed of under current market conditions. Only in a cash settlement market in which the underlying instrument price may not reflect the correct price is there a problem. It has been argued, as a result, that in cash settlement contracts early exercise should not be permitted.

FIGURE 2

S&P 100 Option Arbitrage Opportunities Based on Daily Closing Prices

(A = 1 Observation, B = 2 Observation, etc.)



IV. Cash Settlement

Concerns about expiration price effects are not new to index futures and options. Such concerns were expressed with respect to individual stock options. Klemkosky (1978), and Officer and Trennepohl (1981) find some evidence of price effects in the days prior to the expiration of individual stock options. However their results are not consistent and the effects are small.

Indices underlying futures and options represent the entire market and therefore are deeper and broader than the market in any stock. As a result, one would expect price effects to be less likely in index futures and options than in individual stock options. However, the cash settlement feature of index futures and options has the potential to result in a stock market price effect at expiration. At expiration, an arbitrager cash settles the profit or loss on the futures or options position at the closing value of the stock market index. As a result, the arbitrager is unaffected by the manner in which the position in the index stocks is unwound so long as the closing price on each of the stocks is received. For example, an arbitrager with a long position in the 20 MMI stocks and a short position in the corresponding futures must sell the MMI stocks in order to unwind the arbitrage position. If the process of selling the individual stocks pushes down the closing value of the index, the futures contract will also settle at a lower price. Since the arbitrager is perfectly hedged, the loss on the stocks is offset by the gain on the short futures position. Cash settlement guarantees convergence of the futures and spot price at maturity, and convergence guarantees a perfectly hedged arbitrager the arbitrage profit calculated when the position was established regardless of the index value at expiration.

To assure receipt of the closing price in each of the index stocks, the arbitrager places market-on-close (MOC) orders with the New York Stock Exchange specialist. MOC orders are market orders to be executed at the closing price on the expiration day. If many substantial arbitrage programs are all unwound in the same direction late on the expiration day, an imbalance in orders may result that forces closing prices in one direction or the other. If the direction of the unwinding is predictable or if sufficient notice is given by market participants intending to unwind arbitrage positions, the specialist and other market participants have time to react and assemble orders on the

other side. On the other hand, if the unwinding is unexpected and generates an unexpected imbalance in orders, price effects may result. The New York Stock Exchange, in recognition of possible unexpected order imbalances resulting from arbitrage unwinding, has issued Information Memorandum Number 85-141 (November 14, 1985) that requests early notification of the intent to place MOC orders and specifies rules for handling MOC orders. In addition, the information memorandum notes that there is no guarantee that MOC orders will be executed.

V. Open Interest and Volume Behavior Around Expiration

In this section, open interest in futures and options contracts on expiration days is first examined; for if open interest is not large on expiration days, no potential for large stock market volume arising from the unwinding of futures and options positions would arise. Second, stock market volume on expiration days is examined.

A. Futures

In futures contracts specifying cash settlement, the fraction of contracts held to expiration exceeds the comparable fraction held to expiration in futures contracts calling for delivery. This is due to the natural reluctance of shorts in delivery markets to take delivery from longs of items about which there is some uncertainty on the dimensions of quality and time of delivery. Table 10 presents data on index futures contracts. Except for the Value Line contract, in excess of 35 percent of average monthly open interest (in all series) is held to maturity and cash settles. In traditional agricultural futures contracts and most financial futures contracts, deliveries would constitute a much smaller fraction of open interest. According to CFTC data for

TABLE 10

Index Futures
Average Month-End Open Interest and
Number Contracts Cash Settled
Year Ending 9/30/85

Futures Contracts	Av. Month-End Open. Interest in Contracts	Av. Nr. of Contracts Per Expiration Cash Settled	Percent Cash Settled
S&P 500	57,049	21,994	38.6
NYSE Composite	9,860	3,609	36.6
Major Market	10,992	6,102	55.5
Major Market MAXI	1,753	1,079	61.6
Value Line	7,111	1,108	15.6

Source: CFTC, Annual Report, 1985.

grains, approximately 12 percent of average monthly open interest was delivered in 1985.

A more detailed picture of the pattern of open interest around eight expiration days in 1984 and 1985 is shown in Table 11 for the S&P 500 futures contract. For example, on December 20, 1985, the open interest in the expiring contract was 27,116, which is approximately one-half of the open interest in that contract (54,428) outstanding on the preceding expiration day. At the expiration date of the

TABLE 11

S&P 500 Futures Contracts
Open Interest Day Before, Day Of, and Day After
Expiration Day
1984–85

Date	Expiring Contract	Next Maturity
12/19/85	27,058	56,627
12/20/85	27,116	59,748
12/23/85	0	59,594
9/19/85	20,522	52,479
9/20/85	17,177	54,428
9/23/85	0	54,131
6/20/85	23,268	52,519
6/21/85	23,324	56,587
6/24/85	0	57,691
3/14/85	27,123	48,815
3/15/85	26,989	51,411
3/18/85	0	52,153
12/20/84	22,216	39,378
12/21/84	20,484	42,866
12/24/84	0	42,678
9/20/84	11,413	27,502
9/21/84	9,752	30,815
9/24/84	0	29,768
6/14/84	14,226	26,000
6/15/84	13,863	27,871
6/18/84	0	26,849
3/14/84	15,535	23,498
3/15/84	14,176	26,472
3/16/84	0	26,201

Source: CME

nearby contract, the open interest in the next maturity (59,748 on December 20, 1985) has grown close to its peak level. At the same time the open interest in the expiring contract remains quite large, which causes the total open interest in all contracts to reach a peak around expiration days. The decline in the open interest of the expiring contract and the increase in the open interest of the next maturity suggests that a substantial portion of the open interest is rolled over into the next maturity. Nevertheless, a substantial fraction of the open interest in the expiring contract remains outstanding at expiration.

If the entire open interest at expiration were to imply stock market trading in the corresponding amount, volume on the stock market would be affected significantly. For example, the open interest on December 20, 1985 represents contracts in $2.711 billion of stocks, which compares with daily New York Stock Exchange volume of about $4 billion. The implication of the open interest for stock market trading is, of course, unclear. First, for every long in the futures market, there is a short. Thus, it is possible that short futures positions may sell stock, while long futures positions may buy stock and that no imbalance of trading is implied in the stock market. This is possible, for example, if both long and short arbitrage opportunities arose during the life of the contract and were held to expiration. Second, some of the open interest may reflect spreaders that have bought the expiring contract and sold the next maturity. If the nearby futures price is depressed at expiration day, this is a desirable strategy. The spreader may buy stocks to replace the long futures position in the expiring contract; and this may offset the sales of stock by long arbitragers. Finally a portion of the open interest may represent speculators on both the long and short side that offset each other.

Nevertheless, a large open interest on expiration day could portend a large unwinding of arbitrage positions in the stock market. Since open interest figures are public, the stock market can predict the potential source of volume generated by expiring futures contracts. However, the degree of imbalance between buyers and sellers of stocks remains uncertain.

B. Options

The available data on option expirations is not as detailed as that for futures expirations. The data in Table 12 give aggregate figures on the number of option contracts exercised in each month of 1985 as well as the number exercised on the expiration day in each of those months. Index options constitutes 96 percent of the volume of trading of the options represented in the table. Since the desirability of exercise depends on whether an option is in the money or not, one can

TABLE 12

Non-Equity Options[1]
Number of Contracts of Open Interest and
Number of Contracts Exercised, 1985

Month	Calls			Puts		
		Exercises			Exercises	
	Open Interest	Current Month	Expiration Day	Open Interest	Current Month	Expiration Day
Jan.	874,385	105,909	56,987	734,482	48,776	33,281
Feb.	1,068,357	127,958	74,834	655,922	62,037	38,331
Mar.	1,118,266	53,720	39,471	592,560	212,982	125,857
Apr.	957,072	88,738	67,584	644,009	46,513	25,248
May	999,200	152,353	98,478	763,738	26,106	15,031
Jun.	843,286	222,132	154,443	591,705	91,318	23,486
Jul.	952,651	169,158	125,997	682,560	25,273	18,147
Aug.	944,096	45,509	14,145	748,262	180,985	123,484
Sep.	926,221	103,226	53,248	725,100	143,104	78,076
Oct.	940,300	260,914	103,566	960,663	41,541	32,006
Nov.	944,069	344,889	94,561	1,150,344	16,516	15,180
Dec.	1,029,970	362,799	276,897	895,889	40,413	31,471

Source: Options Clearing Corp Statistical Reports

[1]The data in the table are aggregate data for the five options exchanges (CBOE, AMEX, PHILA, PSE, NYSE) and the NASD for the non-equity options, that is for all index options, T-bond and T-note options, and foreign currency options for all expiration months. Index options constitute 96.09% of the volume of trading in these intruments in 1985.

expect a considerable difference between puts and calls in the frequency of exercise. Taking the maximum number of contracts exercised on the expiration day (i.e. between puts and calls) as a fraction of the corresponding open interest yields an average expiration day exercise percentage of 13.2 percent for 1985. This rate is considerably lower than the fraction of open interest cash settled in futures market. It represents approximately 132,000 contracts, which have an underlying value of about $2.640 billion.

Thus, the potential volume effect in the stock market is approximately the same for options contracts as for futures contracts. But as in the case of futures, holding an option until expiration need not imply stock market volume. Options positions may be rolled over into more distant maturities. In addition, many holders of options may have a long term position in the underlying securities that they have no intention of changing. For example, institutional option writers sell options to earn additional income but have no intention of selling the underlying shares.

C. Stock Market

The evidence in Tables 13 and 14 makes it is clear that stock market volume has been affected by index futures expirations and, to some degree, by options expirations. Table 13 presents data on block transactions and reported share volume for weeks in which neither the S&P 100 options nor the S&P 500 futures expired on Friday, for weeks in which only the options expired on Friday and for weeks in which both the options and futures expired on Friday. Table 14 presents summary data for ratios of Friday volume to average daily volume in the week and for last hour volume on Friday relative to average hourly volume on Friday. Table 14 is somewhat more appropriate since it controls for variations in the number of trading days per week and for seasonal fluctuations in weekly volume. It is evident from this table that volume of trading in the last hour of Friday is significantly higher when futures and options expire, than on other Fridays. On quarterly Friday expirations, volume in the last hour is 58 percent higher than in other hours of that Friday. On non-expiration Fridays, last hour volume is typically somewhat less than the average hourly volume during the rest of the day. Furthermore, since volume on quarterly expiration Fridays exceeds average daily volume by 8 percent, the absolute volume during the last hour exceeds the absolute volume on non-expiration Fridays by considerably more than 58 percent. Indeed, Table 13 indicates that the average last hour volume on quarterly expiration Fridays is about twice the average absolute volume

TABLE 13

NYSE Volume Data Classified by Friday-Expiration Type[1]
Weekly Data
December 30, 1983 to December 27, 1985

	Number of Blocks[3]		Share Volume (1000's)		
	Per Week	On Friday	Per Week	On Friday	Last Hour
Non-Expirations					
Mean	9,204	1,924	474,896	99,049	15,959
St. Deviation	2,358	589	110,124	27,158	5,011
Observations	81	81	81	81	81
Options-Only Expirations					
Mean	9,707	1,997	493,404	101,483	17,891
St. Deviation	2,246	597	105,051	28,870	5,073
Observations	17	17	17	17	17
Futures and Options Expire[2]					
Mean	10,036	2,134	536,999	115,660	31,156
St. Deviation	2,459	486	118,880	27,490	11,612
Observations	7	7	7	7	7

Source: Barrons

[1]Expiration type is based on the S&P 500 futures and the S&P 100 options.

[2]Since data is classified by Friday expiration type, the March 1984 S&P futures expiration, which was on Thursday, is not included here. In that week futures expired on Thursday and options expired on Friday.

[3]Blocks are transactions of 10,000 shares or more.

on non-expiration Fridays.

While stock market volume on option expirations is higher than on non-expirations, the effect is small when compared with the quarterly expirations when futures and options expire.

The highest volume Friday does not necessarily occur on expiration days. If one ranks all Fridays on share volume, only one quarterly expiration is in the top ten in terms of volume and only two quarterly expirations are in the top twenty in terms of volume of trading. On the other hand, volume in the last hour of Friday is greatest on the quarterly Friday expirations.

Although volume on expiration Friday is large, it does not exceed non-expiration Friday volume by as much as would be implied by the expiration day open interest in Table 10. For the years 1984-1985, average Friday stock market volume on quarterly expirations was 115,660,000 shares, or about $4.088 billion, while average

volume on non-expiration Friday was 99,049,012 shares or about $3.467 billion. This difference is about ⅓ the amount that would be implied if the average open interest of 19,815 contracts or about $1.783 billion existing on expiration Friday were traded in the stock market.

TABLE 14

Relative NYSE Volume on Fridays Classified by Expiration Type
Weekly Data
December 30, 1983 to December 27, 1985

	Nr. of Friday Blocks as a Fraction of Avg. Nr. of Daily Blocks in the Week	Friday Share Volume as a Fraction of Avg. Daily Share Volume in the Week	Share Volume in Last Hour as a Fraction of Avg. Hourly Friday Share Volume
Non-Expiration Fridays			
Mean	1.004	1.002	.9720
Standard error	.0189	.0174	.0194
Observations	81	81	81
Options-Only Expirations			
Mean	1.020	1.018	1.080
Standard error	.0483	.0463	.0100
Observations	17	17	17
Futures and Options Expire			
Mean	1.072	1.080	1.584
Standard error	.0486	.0470	.0253
Observations	7	7	7

Source: Barron's.

VI. Stock Market Price Effects

In this section, we examine stock market price effects associated with expirations of options and futures. Since the unwinding of arbitrage positions could cause price pressures either in an upward or downward direction, the emphasis is on the volatility of prices at expiration. Secondly, since we are concerned with abnormal price changes, we seek reversals of prices. If a price change on the expiration day is abnormal and is caused by selling pressure or buying pressure, the price would tend to return to a normal level on the following day. Figure 3 illustrates the interpretation of price reversals after a price decline. If the price fails to reverse after a decline, the decline is judged to be the result of new information that justifies a new lower price. If the price reverses part of the way (the top figure), the reversal portion of the initial decline is judged to be unjustified by new information and is ascribed to the price impact of the transaction. If the price reverses by more than initial decline (the bottom figure), the entire initial decline is judged to be the price impact and the excess reversal is judged to be the result of information. A corresponding interpretation applies to price reversals after a price increase.

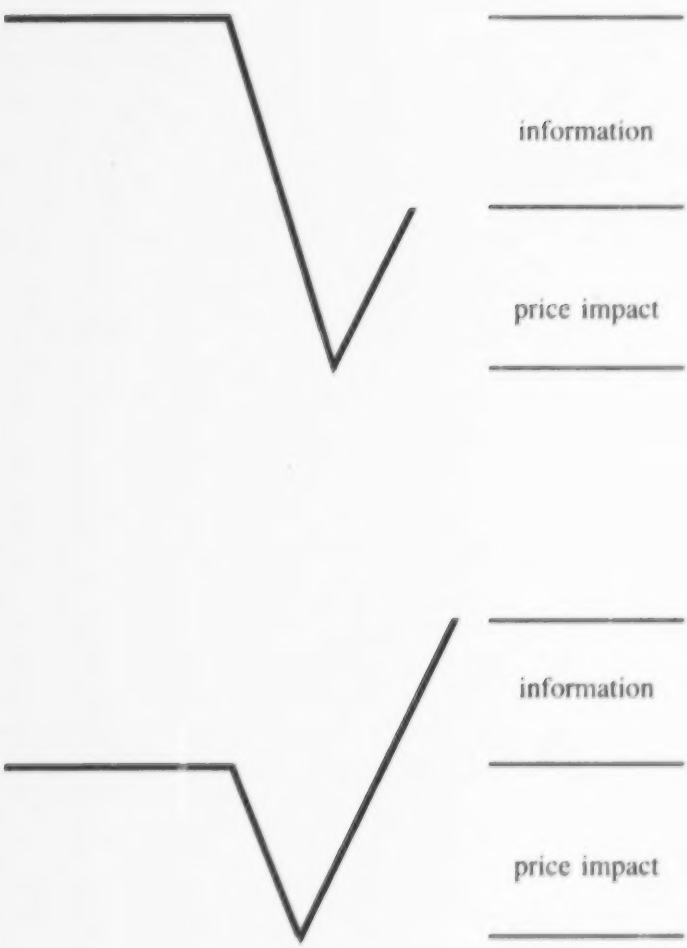
Expiration day price effects have been examined by Birinyi and Hanson (1985) and by the Chicago Mercantile Exchange (1985) in its letter to the CFTC of December 4, 1985. Academic studies have examined daily patterns of stock market returns, although expiration day returns have not been examined per se. See, for example, the papers by Harris (1984), Keim and Stambaugh (1984), and Rogalski (1984). A variety of data sets are examined in this study:

1. Daily closing prices of the S&P 500, S&P 100, MMI, NYSE, and Value Line indices. These data were kindly supplied by the CBOE and cover all days since trading in index futures and options began.

2. Hourly prices for Friday of every week, Thursday closing prices, and Monday prices one-half hour after the open. (When the S&P 500 futures expire on Thursday, data are centered on Thursday rather than Friday). These prices are available for the S&P 500, S&P 100, NYSE, and Value Line indices and were kindly supplied by the Chicago Mercantile Exchange.

FIGURE 3

Interpretation of Price Reversals



3. Minute-by-minute prices for the S&P 500 and MMI Indices for all days since futures contracts have been traded on these indices. Data were kindly supplied by the Chicago Mercantile Exchange and Chicago Board of Trade respectively.

We typically report results only for the S&P 500, S&P 100 and MMI Indices. The analysis proceeds from the least detailed data sets to the most detailed data sets.

TABLE 15

Mean and Standard Deviation of Expiration Day Percentage Returns
S&P 500 Index, S&P 100, MMI Index
by Type of Expiration
May, 1982 to December, 1985

Index	S&P 500 Futures Expire	CBOE Options/ Not S&P 500 Futures Expire	Nothing Expires
S&P 500			
Mean Return	−.244	.000	.130
St. Deviation	.827	.627	.769
Observations	15	19	141
S&P 100			
Mean Return	−.314	−.021	.038
St. Deviation	.872	.756	.870
Observations	14	18	134
MMI			
Mean Return	−.323	−.019	.045
St. Deviation	.820	.757	.867
Observations	14	18	134

Notes: Returns are Thursday close to Friday close except in the case of S&P 500 futures expirations before 3/14/84. Before that time, expiration occurred on Thursday and returns are Wednesday close to Thursday close. To calculate mean and standard deviation when no index futures or options contract expires, one day per non expiration week is used—Thursday until 3/22/84, Friday thereafter.

Data are daily returns based on closing prices and cover the period April 1982 to December 1985.

The null hypothesis of equality of the mean or standard deviation on expiration and non-expiration days is not rejected at the 5% level of significance for any of the cases in this table.

A. Price Effect in Daily Closing Prices

Table 15 compares means and standard deviations of returns on S&P 500 futures expirations, on CBOE option expirations when S&P 500 futures do not expire, and on days when no futures or option contract expires. The volatility of daily returns, as measured by the standard deviation, is not significantly different on expiration days than on other days. In the case of the S&P 500 index, for example, volatility is somewhat higher than normal when the S&P 500 futures expire and somewhat lower than normal when only options expire, but neither of these differences is statistically significant.

An indication that expirations may have price effects is

TABLE 16

Mean Absolute Percentage Return $|R_t|$, Mean Subsequent Day Reversal and Correlation Between Expiration Day Return and Subsequent Day Return Based on Daily Closing Prices for S&P 500, S&P 100, MMI Indexes by Type of Expiration May, 1982 to December, 1985

Index	S&P 500 Futures Expire	CBOE Options, Not S&P 500 Futures Expire	Nothing Expires
S&P 500			
Expiration Day $\|R_t\|$	.730	.508	.590
Reversal	−.190	.369	.088
Correlation (R_t, R_{t+1})	−.250	.036	.193
S&P 100			
Expiration Day $\|R_t\|$	.768	.618	.668
Reversal	−.150	.509	−.036
Correlation (R_t, R_{t+1})	−.260	−.101	.109
MMI			
Expiration Day $\|R_t\|$	.717	.657	.647
Reversal	−.417	−.041	.064
Correlation (R_t, R_{t+1})	−.090	.057	.138

Notes: Same data as preceding Table. "Nothing expires" column considers Thursday or Friday on which no option or future expired.

contained in Table 16, which analyzes the extent to which price reversals are observed after expiration days. For each price index, the absolute return on the expiration day is calculated—$|R_t|$. If the return on the next day is of opposite sign, it is given a negative value. Average values of this variable are reported in the row labeled "reversal." The absolute value of the expiration day return is a measure of volatility of the return, not a measure of the return itself. The results in Table 16 for volatility measured in this way correspond to the results in Table 15. Only in futures expirations does one observe a reversal in all three price indices and this is indicative of a price effect. Reversals are not observed when options alone expire. The serial correlation coefficient between the expiration day return and the subsequent day return is also negative in the case of S&P 500 futures expirations, whereas it is normally positive. Positive serial correlation can result if the stock market moves late in the day but not all stocks trade at the close. In that case, price changes in some of the stocks may not be registered in the index until the following day, which induces positive serial correlation.

B. Last Hour Price Effects

Because price effects are said to be concentrated in the last hour of trading when volume is high, we next examine last hour returns (Tables 17 and 18). The data span the period July 1983 to December 1985 and therefore omit some of the early S&P 500 futures expirations that are included in the daily analysis.

Table 17 shows that the volatility of the S&P 500 index and the S&P 100 index are significantly higher on futures expiration days than on non-expiration days. The asterisk in the table indicates that the null hypothesis of equal means or equal standard deviations between expiration days and non-expiration days is rejected at the 5 percent probability level or lower. The test of means is a t-test. The test of standard deviations is an F-test. The table also indicates that returns on futures expiration days tend to be negative. Option expirations appear to lead to a somewhat higher than normal volatility for the S&P 100 index, but not for the S&P 500 index. The table also examines the behavior of New York Stock Exchange stocks not in the index by subtracting the S&P 500 or S&P 100 index return from the NYSE index return (properly adjusted for the weighting of each of these indices). The behavior of New York Stock Exchange stocks not in the S&P 500 index is no different on expiration days than on non-expiration days. In other words the expiration day effect seems to be associated with those stocks that might be part of a position unwinding,

TABLE 17

Mean and Standard Deviation of Last Hour Expiration Day Percentage Returns by Index Type and Expiration Type July 1, 1983 to December 27, 1985

Index	S&P 500 Futures Expire	CBOE Options/ Not S&P 500 Futures Expire	Nothing Expires
S&P 500			
Mean	−.352*	.026	.061
St. Deviation	.641*	.261	.211
Observations	10	16	97
S&P 100			
Mean	−.452*	−.007	.033
St. Deviation	.699*	.401*	.252
Observations	10	16	97
Non S&P 100 Stocks[1]			
Mean	.064	.079	.077
St. Deviation	.230	.211	.264
Observations	10	16	97
Non S&P 100 Stocks[1]			
Mean	−.168	.059	.079
St. Deviation	.423*	.202	.160
Observations	10	16	97

Data base contains Thursday close, hourly index values for Fridays and Monday 10:30 prices (East) for every week in the period July 1, 1983 to December 27, 1985 except that data are centered on Thursday when the S&P 500 futures expire on Thursday. Data kindly supplied by CME.

*An asterisk indicates that the null hypothesis of equality of the mean or standard deviation on expiration and non-expiration days is rejected at the 5% level of significance. That of means is a t test. That of standard deviation is an F test.

[1]Value weighted index of non S&P 500 stocks for which return is defined by R_X in the following equation

$$R_{ny} = k\,R_I + (1-k)\,R_X$$

where

R_{ny} = NYSE Composite Index
R_I = Return on S&P 500 or S&P 100 Index
R_X = Return on portfolio of stocks excluded from S&P 500 or S&P 100 index
k = Fraction of NYSE index in S&P 500 or S&P 100 Index. For S&P 500 Index, k = .79. For S&P 100 Index, k = .34.

not with stocks that would not be a part of an arbitrage position. New York Stock Exchange stocks not in the S&P 100 index do exhibit a slightly negative return and a somewhat higher standard deviation of return on futures expiration days than on non-expiration days. This is presumably due to the fact that many of these stocks are in the S&P 500 index.

Table 18 presents analysis of return reversals between the last hour on the expiration day and the first half hour on the following day. The average reversal when futures expire is 0.38 percent in the S&P 500 index and 0.532 percent in the S&P 100 index. Serial

TABLE 18

Mean Absolute Percentage Return in Last Hour $|R_t|$, Mean Reversal[1] Between Close and 10:30 (East) Next Trading Day, and Correlation Between Last Hour Return and Return to 10:30 (East) Next Trading Day By Type of Expiration
July 1, 1983 to December 27, 1985

Index	S&P 500 Futures Expire	CBOE Options, Not S&P 500 Futures Expire	Nothing Expires
S&P 500			
Expiration Day $\|R_t\|$	.608	.176	.172
Reversal	−.380	−.098	.004
Correlation (R_t, R_{t+1})	−.343	−.015	.099
S&P 100			
Expiration Day $\|R_t\|$	.748	.276	.194
Reversal	−.532	−.182	−.240
Correlation (R_t, R_{t+1})	−.326	−.329	.045
Non-S&P 500 Stocks			
Expiration Day $\|R_t\|$	.162	.176	.157
Reversal	.610	−.059	−.078
Correlation (R_t, R_{t+1})	−.071	−.012	.023
Non-S&P 100 Stocks			
Expiration Day $\|R_t\|$	.380	.162	.134
Reversal	−.463	.005	−.029
Correlation (R_t, R_{t+1})	−.247	.284	.217

Source: Data same as preceding table.

[1]A reversal is indicated by a negative sign; a positive sign means that the price continued in the same direction on day t + 1.

correlation of returns is also negative. No reversal is found for non S&P 500 stocks, and a reversal of 0.463 percent is found for non S&P 100 stocks. Small reversals are observed when CBOE options (not futures) expire, but the largest of these—for the S&P 100 index—is smaller than the reversal on days when nothing expires (0.182 percent versus 0.240 percent).

C. Minute-by-Minute Price Data

Minute-by-Minute data for the S&P 500 and MMI Indices are used to analyze each expiration day separately. Examination of these data indicates that, when expiration day price effects occur, the effects are concentrated in a very short period of time near the close.

Detailed minute-by-minute plots of index prices over the last half hour of the expiration day and the first half hour of the next day are contained in the Appendix. The 4 PM (Eastern time) index value and the closing index value are shown explicitly in (most of) the figures. The difference in the two values reflects the fact that all index stocks have not finished trading exactly at 4 PM, particularly on very active days. Transactions sometimes take another 15 minutes to complete and report. Classic short run price reversals centered at the closing price are observed in three of the seven Friday futures expirations (3/15/85, 6/21/85, 9/20/85). These effects have been widely reported in the press. Price reversals are also observed in 11 of the 14 options-only expirations for which plots are available. In futures expirations, the closing price reaches a trough in two of the three reversals. In options, the closing price reaches a trough in only 4 of the 11 reversals.

The figures for expiration days do not show whether a similar pattern may be found for non-expiration days. Work by Harris (1984), covering the period December 1981 to January 1983, shows that stock prices typically increase in the last 15 minutes of trading. This pattern is consistent during every day of the week. Harris also finds that returns tend to be negative in the first 15 minutes of Monday morning, while they tend to be positive on other mornings of the week. Furthermore, Rogalski (1984) has shown that returns between Friday close and Monday open tend to be negative. The pattern of prices found by Harris and Rogalski would explain the expiration price peaks observed particularly in the case of options expirations. Their results would not be consistent with Friday troughs.

Because the scales of the figures are quite small, the magnitude of the price reversals may be exaggerated. When options alone expire, the reversals are quite small, less than 0.5 index points

except in one instance. When options and futures expire on Friday, reversals tend to be larger in those instances where reversals occur. Tables 19 and 20 provide data on S&P 500 and MMI index values 30 minutes before the close, at the close, at the next day's open and 30 minutes after the next day's open. Corresponding 30 minute returns and 15 minute returns are calculated. These data are used to estimate the magnitude of reversals.

Let

R_t = return in last 30 minutes of expiration day

R_{t+1} = return in first 30 minutes of following day

A reversal occurs if $\text{sign}(R_t) \neq \text{sign}(R_{t+1})$. The magnitude of the reversal is defined in two ways, X_{1t}, X_{2t}:

1. If $\text{sign}(R_t) \neq \text{sign}(R_{t+1})$,

$$X_{1t} = |R_{t+1}|, \text{ 0 otherwise.}$$

2. If $\text{sign}(R_t) \neq \text{sign}(R_{t+1})$

$$X_{2t} = \min(|R_t|, |R_{t+1}|), \text{ 0 otherwise.}$$

The second definition, X_{2t}, takes account of the fact, pointed out in Figure 3, that a reversal in excess of the initial price change reflects new information, not price impact.

Table 21 presents average value of X_1 and X_2 based on the data in Tables 19 and 20. The largest average type 1 reversal is 0.445 percent over the seven Friday S&P 500 futures expirations. This figure is comparable to the 0.38 percent reversal in Table 18, in which the 10 futures expirations between 9/15/83 and 12/20/85 are considered. The type 2 reversal averages 0.280 percent over the seven Friday futures expirations. Three of the seven Friday futures expirations experience type 2 reversals in excess of 0.25 percent. The average value of these three type 2 reversals is 0.54 percent. No Thursday futures expiration reversals are this large, and only two of fourteen options-only expiration reversals are as large as 0.25 percent.

D. Economic Significance of Price Effects

The economic significance of the price effect as reflected in the reversal must be evaluated against some standard and ultimately against the cost of eliminating the effect. The bid-ask spread on the index is approximately 0.5 percent. On a normal day one might expect

half the stocks in the index to be trading at the bid and half the stocks to be trading at the ask so that the index price represents a price midway between the bid and the ask. If an arbitrage unwinding necessitates the simultaneous sale of the stocks in the index, all the stocks will sell at the bid price on the floor of the stock exchange. This price would be approximately 0.25 percent below the previous transaction price and would therefore imply a price effect of 0.25 percent. Thus a substantial portion of the price reversal of about 0.4 percent (Tables 18, 21) observed in quarterly Friday expirations can be explained by the normal price impact of trading. Traders unwinding positions before maturity, when a greater incentive exists to minimize price effects, expect to induce price effects of this magnitude. The type 2 measure of price reversal, an average value of 0.28 percent (Table 21), can be explained almost entirely by the normal market impact of trading.

Price reversals in excess of those on futures expiration days are observed quite frequently in block transactions. Kraus and Stoll (1972) find an average price reversal of .71 percent in the case of block sales in excess of $1 million in the period 1968-69. Holthausen, Leftwich and Mayers (1985) find a comparable effect for the largest block sales on each of the 228 trading days in 1982. Large blocks are defined in terms of normal volume, in terms of company size or in terms of absolute dollar value. When the largest block on each day is, for example, chosen on the basis of size relative to normal daily volume in the stock, an average price reversal of 1.11 percent is observed. However, block transactions, other than on expiration days, do not necessarily occur simultaneously in many stocks. What is different about expiration days is that price pressure in the same direction occurs in a large number of different stocks and is therefore reflected in the index.

Neither the price effects on expiration days nor the price effects of block transactions are desirable. They reflect the additional costs of trading large amounts of stock quickly that an operationally more efficient market might avoid. Unknowing investors might be adversely affected by temporary price changes associated with blocks or futures expirations if they sell at a temporary trough or buy at a temporary peak. Most temporary price moves tend to be quite brief. In contrast to block transactions, expiration days have the advantage of being predictable.

TABLE 19A

S&P Futures Contract Expiration Day Effects
April 21, 1982 through December 31, 1985
Rates of Return on the S&P 500 Index
during the Last Minutes of Expiration Day and
the Opening Minutes of the Day after Expiration

Exp. Date t	Exp. Date t+1	Index Level				Rates of Return			
		Close -30	Close	Open	Open +30	Last 30 t	First 30 t+1	Last 15 t	First 15 t+1
820617	820618	107.77	107.60	107.60	107.37	−0.158	−0.214	−0.009	−0.139
820916	820917	123.85	123.77	123.76	123.27	−0.065	−0.396	0.081	−0.242
821215	821216	135.43	135.24	135.22	135.69	−0.140	0.348	0.044	0.259
830317	830318	149.54	149.59	149.59	149.86	0.033	0.180	0.027	0.074
830616	830617	169.31	169.14	169.11	168.94	−0.100	−0.101	−0.100	−0.089
830915	830916	164.92	164.38	164.39	164.50	−0.327	0.067	−0.231	0.024
831215	831216	162.25	161.66	161.66	161.96	−0.364	0.186	−0.210	0.136
840315	840316	157.84	157.41	157.46	160.10	−0.272	1.677	−0.241	0.845
840615	840618	149.57	149.03	149.02	148.81	−0.361	−0.141	−0.268	−0.268
840921	840924	166.40	165.67	165.67	165.99	−0.439	0.193	−0.072	0.109
841221	841224	164.65	165.53	165.50	165.98	0.534	0.290	0.133	0.290
850315	850318	177.97	176.53	176.53	177.03	−0.809	0.283	−0.563	0.317
850621	850624	188.02	189.61	189.50	187.93	0.846	−0.828	0.021	−0.649
850920	850923	182.96	182.05	182.12	184.60	−0.497	1.362	−0.328	1.065
851220	851223	210.60	210.94	210.94	210.00	0.161	−0.446	0.200	−0.465

TABLE 19B

S&P 100 Option Contract Expiration Day Effects
March 18, 1984 through December 31, 1985
Rates of Return on the S&P 500 Index
during the Last Minutes of Expiration Day and
the Opening Minutes of the Day after Expiration

Exp. Date t	Exp. Date t+1	Index Level				Rates of Return			
		Close −30	Close	Open	Open +30	Last 30 t	First 30 t+1	Last 15 t	First 15 t+1
840419	840423	157.83	158.02	158.02	158.02	0.120	0.000	0.184	−0.057
840518	840521	155.30	155.77	155.80	155.99	0.303	0.122	0.225	0.019
840720	840723	149.15	149.55	149.55	147.91	0.268	−1.097	0.268	−0.822
840817	840820	164.11	164.14	164.14	163.90	0.018	−0.146	0.091	−0.085
841019	841022	167.60	167.96	167.96	167.46	0.215	−0.298	0.305	−0.363
841116	841119	164.51	164.10	164.17	164.23	−0.249	0.037	−0.110	0.085
850118	850121	171.00	171.32	171.31	171.74	0.187	0.251	0.216	0.152
850215	850219	181.63	181.60	181.61	181.10	−0.017	−0.281	0.177	−0.270
850419	850422	180.83	181.11	181.11	180.98	0.155	−0.072	0.094	0.050
850517	850520	187.90	187.42	187.50	189.33	−0.255	0.976	−0.181	0.779
850719	850722	194.65	195.13	195.13	194.48	0.247	−0.333	0.221	−0.323
850816	850819	186.76	186.12	186.14	186.46	−0.343	0.172	−0.118	0.134
851018	851021	187.19	187.04	186.98	187.08	−0.080	0.053	0.016	0.021
851115	851118	198.01	198.11	198.11	198.16	0.051	0.025	0.056	−0.056

TABLE 20A

S&P 500 Futures Contract Expiration Day Effects
August 7, 1984 through December 31, 1985
Rates of Return on the Major Market Index
during the Last Minutes of Expiration Day and
the Opening Minutes of the Day after Expiration

Exp. Date t	Exp. Date t+1	Index Level				Rates of Return			
		Close −30	Close	Open	Open +30	Last 30 t	First 30 t+1	Last 15 t	First 15 t+1
840921	840924	236.86	235.50	235.50	236.94	−0.574	0.611	−0.536	0.386
841221	841224	237.10	239.10	239.10	240.24	0.844	0.477	0.021	0.456
850315	850318	253.84	250.08	250.08	251.72	−1.481	0.656	−1.263	0.612
850621	850624	257.69	260.07	260.16	257.84	0.924	−0.892	0.767	−0.611
850920	850923	251.49	250.48	250.48	254.01	−0.402	1.409	−0.223	1.254
851220	851223	291.58	292.37	292.34	291.61	0.271	−0.250	−0.385	−0.434

TABLE 20B

S&P 100 Option Contract Expiration Day Effects
August 7, 1984 through December 31, 1985
Rates of Return on the Major Market Index
during the Last Minutes of Expiration Day and
the Opening Minutes of the Day after Expiration

Exp. Date t	Exp. Date t + 1	Index Level				Rates of Return			
		Close − 30	Close	Open	Open + 30	Last 30 t	First 30 t + 1	Last 15 t	First 15 t + 1
840817	840820	237.02	236.91	236.91	236.41	−0.046	−0.211	0.021	−0.034
841019	841022	239.83	241.68	241.68	240.88	0.771	−0.331	0.771	−0.480
841116	841119	237.41	235.38	235.38	236.66	−0.855	0.544	−0.633	0.684
850118	850121	244.30	244.22	244.22	245.25	−0.033	0.422	−0.045	0.307
850215	850219	253.47	253.47	253.47	252.86	0.000	−0.241	0.305	−0.327
850419	850422	251.86	252.75	252.75	253.03	0.353	0.111	0.131	0.222
850517	850520	256.95	254.92	254.92	257.61	−0.790	1.055	−0.651	0.989
850719	850722	265.25	266.16	266.16	265.25	0.343	−0.342	0.267	−0.394
850816	850819	255.83	255.77	255.71	255.88	−0.023	0.066	0.110	0.102
851018	851021	256.96	257.24	257.24	256.59	0.109	−0.253	0.242	−0.210
851115	851118	270.57	270.74	270.74	270.83	0.063	0.033	−0.033	−0.133

TABLE 21

Percentage Return Reversals in First 30 Minutes of Day Following Expiration Day as Compared with Last 30 Minutes of Expiration Day Based on S&P 500 Index 6/17/82 to 12/20/85

	Number of Days	Average Reversal Type 1, $\bar{X}_1$	Average Reversal Type 2, $\bar{X}_2$	Number of Type 2 Reversals Greater Than .25%
S&P 500 Futures Expire on Thursday	8	.285	.087	1
S&P 500 Futures Expire on Friday	7	.445	.280	3
S&P 100 Options, Not Futures, Expire	14	.227	.097	2

Source: Tables 19A, 20A.

VII. Basis Behavior Around Expiration

If the unwinding of arbitrage positions on expiration day causes a temporary distortion of stock index values, one might on the expiration day observe a distortion of the basis—the spread between the spot index value and the future price. Let S_t be the spot index value on expiration day t. Let F_{1t} be the index futures price on the expiring futures contract. Let F_{2t} be the index futures price on the next maturity. On the expiration day $F_{1t} = S_t$ at the close, and the basis is defined as $B_t = (F_{2t} - S_t)/S_t$. The day before expiration, $t-1$, $B_{t-1} = (F_{2t} - F_{1t})/F_{1t}$. The day after expiration, $B_{t+1} = (F_{2t+1} - S_{t+1})/S_{t+1}$. This basis reflects a three-month cost of carry since the S&P 500 futures contracts, which are examined in this analysis, originate on a three month cycle.

The basis values, $(B_t - B_{t-1})$ and $(B_{t+1} - B_t)$, are examined for 14 S&P 500 futures expirations. Since carrying costs (r-d in equation 1) are unlikely to change over a short period of time, one would normally expect little change in the basis. However, if the spot index value is temporarily depressed on expiration day one might observe a widening of the basis so that $(B_t - B_{t-1}) > 0$. On the other hand if the index value rises temporarily, one might observe a narrowing of the basis so that $(B_t - B_{t-1}) < 0$. Average values of the daily basis changes, conditional on the daily S&P 500 index returns are shown in Table 22.

TABLE 22

Average Change in the Basis, B_t, on the Expiration Day and the Day After, Conditioned on the Sign of the Expiration Day Return, R_t, S&P 500 Futures Expirations, 6/17/82 to 9/20/85

	Observations	$B_t - B_{t-1}$	$B_{t+1} - B_t$
$R_t \leq 0$	10	.1281%	.0029%
$R_t > 0$	4	−.2325%	.0338%

$B_{t-1} = (F_{2t-1} - F_{1t-1})/F_{1t-1}$. At t, the expiration day, $F_{1t} = S_t$ and $B_t = (F_{2t} - S_t)/S_t$. $B_{t+1} = (F_{2t+1} - S_{t+1})/S_{t+1}$ where F_1 is the price of the expiring futures contract and F_2 is the next maturity.

A slight distortion of the basis in the expected direction is observed. When the S&P 500 index falls on expiration day, the basis widens on average by 0.1281 percent; but there is not a reversal the next day. When the S&P 500 index increases on expiration day, the basis narrows on average by −0.2325 percent. The largest basis distortion occurred on 6/21/85, when the market rose at the close. In that case, the basis declined from 1.965 percent to 0.654 percent which is a significant change.

A distortion of the basis is desirable, if observed early enough, because it induces new arbitragers to enter the market and generates stock market transactions opposite those associated with the expiring futures. For example, if the index falls on expiration day because arbitragers are unwinding large positions, a widening of the basis induces new arbitragers to enter into a long arbitrage by buying stocks at S and sell futures at F_2 (or induces existing arbitragers to roll over positions).

VIII. Predictability of Expiration Day Price Effects

Although significant price effects have been observed on relatively few expirations, we analyze in this section the ability to predict the direction of expiration day price effects from the arbitrage opportunities observed prior to expiration. If it is profitable to establish a long arbitrage either in futures or options (i.e. long stock and short futures or synthetic short in options), we predict a temporary price decline at expiration as a result of stock sales at the expiration. Conversely, if it is profitable to establish a short arbitrage prior to expiration, we predict a temporary price increase at expiration.

Our predictions face several difficulties. First, both long and short arbitrage opportunities may be observed before expiration. We assume that the most recent opportunities determine the direction of unwinding at expiration. Second, the calculation of arbitrage opportunities is subject to error because we do not have a record of actual dividend payments on the index stocks, but instead make some assumptions about the dividend yield during the period analyzed. Third, when daily closing prices are used, arbitrage opportunities during the day may go unobserved. Finally, there is a more fundamental problem. If a price effect were predictable, traders could profit from the prediction; and by trading would tend to eliminate predictability of the effect. Thus, if the market is efficient, prediction of price effects would not be expected.

A. S&P 500 Futures Expirations, Daily Data

Using the daily closing prices for the S&P 500 Index and the nearby futures contract (the data underlying Figure 1), futures arbitrage opportunities are examined in the period prior to each of the 15 expirations between 6/17/82 to 12/20/85. An arbitrage opportunity is defined as a violation of the bound specified in (2). The total number of long and short arbitrage opportunities prior to each expiration is shown in Figure 1.

The predicted price effect is based on the most recent arbitrage opportunities prior to expiration, and a price effect is defined to exist if a price reversal of any size is observed in S&P 500 index values using the 30 minute returns in Table 19A. In the seven instances in which S&P 500 futures contracts expired on Friday, the prediction rule predicted three price increases and four price decreases. Three of

these seven predictions were correct, hardly a strong showing. In the eight Thursday expirations, the predicted effect was correct in two of the eight expirations. Of the eight expirations, prices fell (and reversed) in three cases and no price effect was observed in five cases. The prediction rule predicted two of the three price declines.

B. S&P 100 Options Expirations, Daily Data

Using daily closing prices for the S&P 100 Index and the nearby options contracts (the data underlying Figure 2), option arbitrage opportunities are examined in the month prior to each of the option expirations in the period 1/20/84 to 11/15/85. Call option expiration days are included in the analysis whether or not futures also expire. An arbitrage opportunity is defined as a violation of the bound specified in (4). The number of long and short arbitrage opportunities prior to each expiration is shown in Figure 2.

As is evident from Figure 2, when arbitrage opportunities arise, they are usually on the short side, which implies an index price increase at expiration. A price effect is defined to exist if a price reversal of any size is observed in the S&P 500 index in the 30 minutes after the expiration day close. (Data in Table 19B and the figures are used to make this classification). The prediction is based on the direction of arbitrage opportunities in the four weeks prior to each expiration.

In ten cases, a prediction of temporary stock price increase at expiration was made, and was correct in four cases. Four predictions called for a temporary stock price decrease at expiration, and two of these were correct. In nine cases, no arbitrage opportunities were observed which should imply no price effect on expiration. However in seven of these nine cases a small temporary price effect was observed. With respect to the common expiration days for futures and options (since 6/15/84), the prediction of futures arbitrage and option arbitrage are the same in two of six cases for which data are available. However this is due primarily to the fact that no arbitrage opportunities in option were observed in four of the cases.

C. S&P 500 Futures Expirations, Minute-by-Minute Data

A more detailed analysis of arbitrage opportunities in S&P 500 index futures was carried out by examining futures prices and index prices at one hour intervals. The ability to predict expiration price effects based on these opportunities was also poor. The results are in Table 23. Column 1 lists the futures contract expiration date. Column 2 lists the total number of hourly observations. The period

from the preceding expiration is examined. The last seven days are excluded because arbitrage opportunities are excessively sensitive to transaction cost assumptions when time to maturity is short. Column 3 counts the number of cases in which the futures price exceeded its theoretical value by more than transaction costs. In these cases, long arbitrage is profitable; and the sales of stock and price declines are predicted for expiration day. (The theoretical value in the table is comparable to that given in (2) except continuous compounding is assumed in deriving the results in the table.) Column 4 counts the number of cases in which the futures price fell below its theoretical value. In these cases, short arbitrage is profitable; and purchase of stocks and price increases are predicted for expiration day. The price changes on the expiration day and the following day are shown in the last four columns. Table 23A assumes a constant dividend yield of 4.13% during the period of analysis. Table 23B assumes a cash dividend payment of $6.50, the amount implied by the dividend yield in March 1984. The actual dividend yield at other times was then based on the cash dividend and the index value at that time.

The tables, like Figure 1, suggest that arbitrage opportunities have declined over time, although the number of opportunities in the December 1984 contract was large. The arbitrage violations have no predictive power. Entries in column 4 are supposed to predict temporary expiration day price increases while entries in column 3 are supposed to predict temporary expiration day price decreases; but an examination of the data shows that such predictions are more often wrong than right.

On the basis of the data we have examined, we conclude that expiration day price effects are difficult to predict. In part this result may be due to inaccuracies in identifying arbitrage opportunities. In part, the result may also be due to the failure to account for rollover possibilities. If arbitragers have a profitable opportunity to roll into the next futures contract, transactions in the stock market may not occur.[7] But, the result also reflects the fact that not many instances of significant price effects have arisen that need to be predicted. That is, many of the price effects on expiration days may be due to factors other than unwinding, which would not be predicted by the direction of an arbitrage opportunity. Finally, predictable price effects would tend to be eliminated by traders who buy stock before an anticipated price increase or sell stock before an anticipated price decrease. Indeed, our inability to predict price effects could be a reflection of the market's ability to predict the direction of unwinding and offset price effects before they occur.

[7] We thank Joanne Hill for stressing this point to us.

TABLE 23A

Prediction of S&P 500 Futures Contract Expiration Day Effects
April 21, 1982 through December 31, 1985
Number of Hourly Violations of Basis Relationship
$F = Se^{(r-d)T}$
Assuming a Constant Dividend Yield Rate of 4.13 Percent
and a Transaction Cost Rate of 0.5 Percent on Stock Purchases and Sales

						Rates of Return			
						S&P 500		Major Market	
Exp. Date	# of Obs.	# of Vio. >	# of Vio. <	Total Vio.	Prop. of Total	Last 30 t	First 30 t+1	Last 30 t	First 30 t+1
820617	252	0	200	200	0.794	−0.158	−0.214		
820916	392	79	178	257	0.656	−0.065	−0.396		
821215	398	104	114	218	0.548	−0.140	0.348		
830317	399	137	27	164	0.411	0.033	0.180		
830616	399	2	167	169	0.424	−0.100	−0.101		
830915	385	8	37	45	0.117	−0.327	0.067		
831215	392	92	2	94	0.240	−0.364	0.186		
840315	385	140	1	141	0.366	−0.272	1.677		
840615	392	1	22	23	0.059	−0.361	−0.141		
840921	434	50	15	65	0.150	−0.439	0.193	−0.574	0.611
841221	406	284	0	284	0.700	0.534	0.290	0.844	0.477
850315	357	149	1	150	0.420	−0.809	0.283	−1.481	0.656
850621	434	87	0	87	0.200	0.846	−0.828	0.924	−0.892
850920	399	45	3	48	0.120	−0.497	1.362	−0.402	1.409
851220	406	1	95	96	0.236	0.161	−0.446	0.271	−0.250

TABLES 23B

Prediction of S&P 500 Futures Contract Expiration Day Effects
April 21, 1982 through December 31, 1985
Number of Hourly Violations of Basis Relationship
$F = Se^{(r-d)T}$
Assuming a Constant Cash Dividend of 6.50 and a
Transaction Cost Rate of 0.5 Percent on Stock Purchases and Sales

Exp. Date	# of Obs.	# of Vio. >	# of Vio. <	Total Vio.	Prop. of Total	Rates of Return			
						S&P 500		Major Market	
						Last 30 t	First 30 t+1	Last 30 t	First 30 t+1
820617	252	0	163	163	0.647	−0.158	−0.214		
820916	392	101	146	247	0.630	−0.065	−0.396		
821215	398	120	105	225	0.565	−0.140	0.348		
830317	399	144	22	166	0.416	0.033	0.180		
830616	399	1	169	170	0.426	−0.100	−0.101		
830915	385	8	39	47	0.122	−0.327	0.067		
831215	392	83	4	87	0.222	−0.364	0.186		
840315	385	134	1	135	0.351	−0.272	1.677		
840615	392	1	23	24	0.061	−0.361	−0.141		
840921	434	47	15	62	0.143	−0.439	0.193	−0.574	0.611
841221	406	278	0	278	0.685	0.534	0.290	0.844	0.477
850315	357	139	2	141	0.395	−0.809	0.283	−1.481	0.656
850621	434	63	2	65	0.150	0.846	−0.828	0.924	−0.892
850920	399	25	6	31	0.078	−0.497	1.362	−0.402	1.409
851220	406	1	133	134	0.330	0.161	−0.446	0.271	−0.250

IX. Countervailing Forces on Expiration Day

On the expiration day, some indication of the unwinding direction is known by market professionals, if only on the basis of their own arbitrage positions. Major broker dealers with stock positions to unwind either for their own accounts or for the accounts of customers have an incentive to inform institutional customers that stock may be available at a good price. The incentive arises from the commissions to be earned on such transactions. The placement of such orders by long term institutional investors can offset the imbalance due to the unwinding and limit the price effect to the amount necessary to induce such institutional investors to enter the market. The price effect is not eliminated because, as in the case of individual block transactions, the offsetting side agrees to a transaction only if the price is favorable.

Interviews with specialists suggests that market-on-close orders are not placed until late in the day, typically in the last half hour. The reason for this is not clear. Arbitragers that are unaffected by the closing price have no reason to postpone the placement of such orders. Certain arbitragers holding market baskets not encompassing the entire index have an interest to take care in an unwinding, since price effects in basket stocks are only partially reflected in the futures. Such arbitragers may fear that an early disclosure of stock transactions may adversely affect the prices of the basket stocks to be unwound. Non-arbitragers taking positions in response to an imbalance generated by an unwinding of arbitrage positions have, perhaps, the greatest reason to postpone notification of their trading intentions in the hopes of achieving a favorable price as the specialist finds it difficult to make up the imbalance.

Interviews also suggests that the book of limit orders is not used more actively on expiration days than on other days. Investors, aware of the potential variability of prices on the expiration day, might "line the book" in the hopes of trading at favorable prices. However, this does not appear to be the case. Instead, the major players monitor market conditions through their floor brokers.

In addition to arbitragers and long term institutional investors, short term traders may be involved in expiration day stock trading. Traders that believe the index will close lower because of arbitrage unwinding, may choose to short sell before the close, an activity which tends to lower prices before the close. To the extent

such activity exacerbates the day's price move, it is undesirable. To the extent it creates incentives to buy stocks, it is desirable. A decline in the index before the close can widen the basis and induce arbitragers to buy stocks and sell the next futures; or alternatively to roll over existing arbitrage positions into the next futures. Holders of long arbitrage positions may also attempt a short term strategy of unwinding stock positions early in hopes of avoiding a later stock price decline. If stock prices do decline later, the profit on the entire short futures position is earned and the losses on the stock position are limited by selling early. This strategy is risky, since late buying pressure may force stock prices up (for example as on December 20, 1985).

As the close approaches, specialists in each stock begin to see the direction of an imbalance in part through the direct placement of orders and in part through communication with various market participants. If the imbalance is too large relative to specialist capital, the specialist solicits floor brokers and other market participants to determine the extent of their buying or selling interest. Floor brokers, in turn, notify upstairs trading desks and may end up placing orders either for institutional customers or for the firm's own account. This communications mechanism, albeit informal, appears to be reasonably effective. Nevertheless, the specialist would obviously be in some difficulty if large orders were to arrive at the close. Since there is a natural reluctance to impose a trading halt especially at the Friday close, a slippage in reporting last sale transactions may result as the specialist quickly attempts to round up orders on the other side at the closing bell.

The mechanism for trading at the close is not unlike that at the opening. The specialist pairs off purchases at the close against sales at the close and calculates the size of the remaining imbalance. The price is increased or lowered relative to the last transaction price on the basis of the size of the imbalance.

Countervailing forces on expiration day—long term institutional investors, spreaders into the next futures contract, and short term traders—have the potential to limit undesirable price effect on the expiration day. Indeed, the limited number of expiration days in which significant price effects have been experienced is an indication that these forces are at play. Knowledge of the direction of unwinding is communicated in a number of ways to market participants. First, prices changes are signals of trading activity. Second floor brokers communicate with specialists and with each other to determine the size of any developing imbalance and to develop strategies for profiting from the imbalance. These activities tend to limit the size of the imbalance. The market's awareness that price changes may occur focuses the attention

of many participants on the stockmarket during expiration days. Competition among such traders tends to limit adverse price effects. Since considerable uncertainty remains on expiration days and since major imbalances could arise at the close, no one is however prepared to predict that price effects will not occur in future expirations.

X. Summary and Conclusions

1. Index futures and options serve important uses as hedging vehicles and as means to implement risk adjusting investment strategies at low cost. Trading in index futures and options, stated in terms of the value in the underlying stocks, exceeds by a substantial margin the volume of trading in the stock market itself, and trading is likely to grow as additional institutional investors become familiar with these new instruments.

2. Arbitrage between futures and underlying stocks or between options and underlying stocks maintains essential pricing linkages between these derivative instruments and the stock market. These linkages are necessary if futures and options are to be useful hedging vehicles and reliable investment management tools in dealing with price fluctuations in the stock market. If futures prices are too high, arbitragers sell futures and buy index stocks. If futures are too low, arbitragers buy futures and sell stocks. A similar arbitrage may be established in options markets. Arbitrage is effective if convergence between futures prices and spot prices is assured at expiration, for then there is no basis risk for the arbitrager with a position in the index stocks. Cash settlement of index futures and options guarantees convergence because futures and options contracts are simply closed out at the closing value of the index on the expiration day.

3. The empirical evidence indicates that arbitrage opportunities appear to have declined in number and magnitude (Figures 1 and 2, Table 23). This reflects the increased awareness of arbitrage opportunities and the availability of capital in the proprietary accounts of brokerage firms as well as the availability of institutional capital to exploit such arbitrage opportunities.

4. Cash settlement of options and futures tends to remove the incentive of arbitragers to take care in unwinding stock positions on expiration day. This arises because the arbitrager has offsetting positions in the stock market and the futures or option markets. So long as stocks are traded at the market closing price, which is the settlement price for futures and options, a loss in one market is offset by a gain in the other market. For example, an arbitrager who is long stocks and short futures is unaffected by the price effects that a sudden sale of all the stocks in his portfolio might cause so long as those sales occur at the market closing price.

5. The empirical evidence for the years 1984 and 1985 indicates that stock market volume is substantially higher in the last hour of trading on the quarterly Friday expirations when futures and options expire together (Tables 13, 14). Volume is higher on quarterly expiration Fridays, but last hour volume on quarterly expiration Fridays is nearly double last hour volume on non-expiration Fridays. Open interest in the expiring futures contracts on the expiration day amounts to about 40 percent of the average month-end open interest, but incremental stock market volume is approximately one third of the volume that would be implied if the entire expiration day open interest were traded in the stock market.

6. Stock market price effects have been examined for all futures and options expiration dates since the inception of these contracts. The emphasis of the study is on the S&P 500 futures expirations—the most active index futures—and the S&P 100 options expiration—the most active index options. Three data sets of stock index prices have been used: (a) Daily closing prices of each index. (b) Hourly index prices on expiration days along with the closing price the prior day and the price the following day one-half hour after the opening. (c) Minute-by-minute prices for the S&P 500 index and the MMI index.

a. While price effects are difficult to detect in daily closing prices, they are observable on quarterly futures expirations if hourly or minute-by-minute data are examined and if the more recent expirations in 1984 and 1985 are considered. The volatility of prices is significantly higher on such expiration days, and the stock market indices tend to fall on such expiration days. (Table 17)

b. No price effect is observed for stocks not in the S&P 500 index. (Tables 17, 18)

c. Price effects are small when options expire and S&P 500 futures do not. That is, price effects seem to be associated with the quarterly index futures expirations. (Tables 17,18)

d. The magnitude of price effects is measured by the degree of reversal in prices on the morning of the trading day after the expiration day, for a price effect that is abnormal will tend to be reversed the next day. The average magnitude of the price reversal associated with the ten most recent quarterly futures expirations is about 0.3 to 0.5 percent of the closing index value on expiration, depending on which index is used and on the method of calculating the reversal (Tables 18, 21). Of

course, on certain expiration days the effect is greater, while on other expiration days there is no effect. Plots of the data show that the largest price reversals occurred on 6/21/85 (a reversal of about 0.85 percent) and on 9/20/85 (a reversal of about 0.5 percent) while reversals were quite limited or non-existent on 6/15/84, 9/21/84, and 12/20/85. (Table 19A, Appendix plots)

7. Expiration price effects must be evaluated against a standard of economic significance. First, a price impact of approximately 0.25 percent of the value of a transaction can be ascribed to the cost of selling at the bid or buying at the ask price. This implies that the average price impact on quarterly futures expirations over and above the price impact that would usually be expected when a position is carefully put on or unwound is about 0.05 to 0.25 percent of the value of the transaction, an amount that represents the additional cost of providing liquidity. Second, price impacts in excess of those found on expiration days occur frequently in large block transactions where the cost of providing liquidity also increases. Academic studies of block sales find average reversals of 0.7 percent and greater, the exact size of this effect depending on how a large block is defined. What is different on expiration days is that transactions in many stocks occur simultaneously so that the market as a whole exhibits an effect that one observes in individual stocks when large blocks trade.

The seriousness of the price effects must also be evaluated in terms of who is hurt by the effect and what the cost would be of some alternative solution. The empirical evidence indicates that the effect is concentrated in a very short period of time, sometimes in the last 15 minutes of trading. Unknowing traders who appear with market orders to sell when an expiration is pushing prices down or who arrive with market orders to buy when an expiration is pushing prices up may be hurt in this period. Block transactions and other events that might adversely affect investors in the same way occur quite frequently and unpredictably. The expiration day phenomenon has the advantage of occurring at a predictable time, which gives investors the option of staying away.

8. Examination of the basis—the percentage spread between the price of the expiring futures and the price of the next maturity (using daily closing prices)—suggests a slight temporary distortion of the basis on expiration days—a widening of the basis when stock prices fall and a narrowing when stock prices rise (Table 22) Such a distortion, if perceived early enough, creates incentives for stock market trading that offsets expiration price effects.

9. We have examined daily data and hourly data to

determine if arbitrage opportunities before the expiration can predict the direction of the price effect on the expiration. The evidence indicates that the direction of the price effect is difficult to predict from such information. (Figures 1, 2, Table 23) While this finding may be the result of poor data or imprecise measurement, it may also imply that markets are working efficiently. If traders can predict the direction of arbitrage unwindings, they can enter into profitable trading strategies that would ultimately limit price effects and make them unpredictable.

10. On the day of expiration, the likely direction of unwinding becomes clearer as arbitragers prepare to unwind positions and notify floor brokers, and countervailing forces come into play as institutional traders and futures market spreaders look for good prices in stocks. But, according to upstairs traders and specialists, uncertainty about the direction and magnitude of order imbalances remains until a closing price is actually established.

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Appendix

PLOTS OF MINUTE-BY-MINUTE PRICE DATA

Stock index values are plotted during the last 30 minutes of the expiration day and the first 30 minutes of the next trading day.

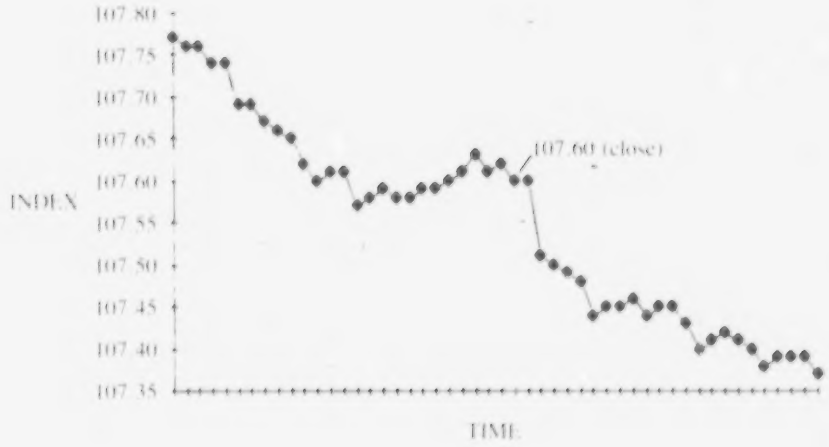
The following plots are contained in this appendix:

1. Thursday expirations of the S&P 500 futures contract, 820617 to 840315. (8 plots).

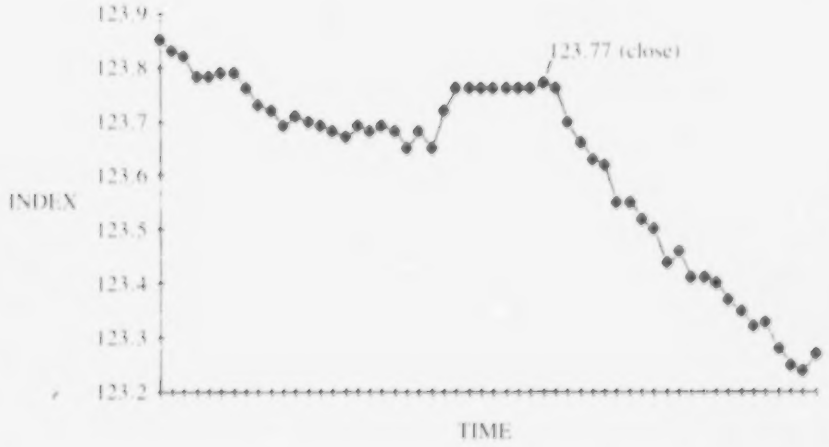
2. Friday expirations of the S&P 500 futures contract, 840615 to 851220. (7 plots).

3. S&P 100 options expirations when S&P 500 futures do not expire, 840419 to 851115. (14 plots).

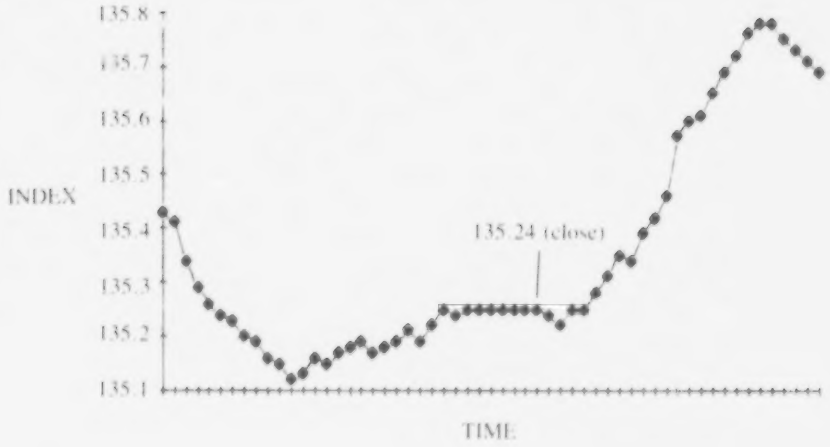
A2
S&P 500–820617



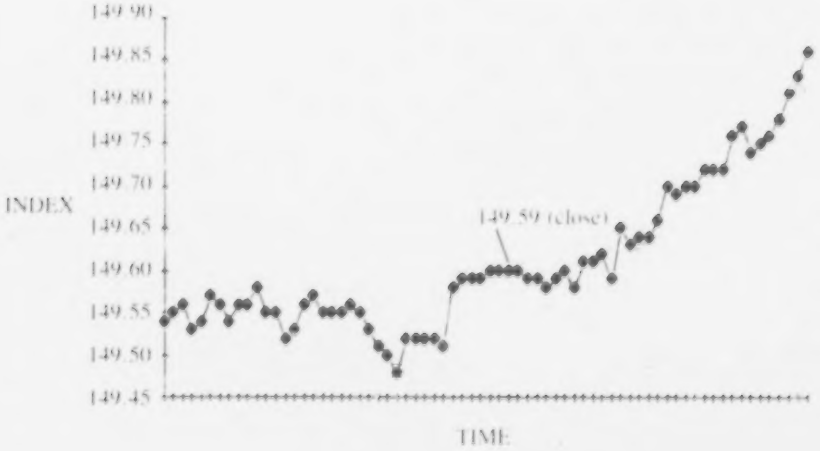
A3
S&P 500–820916



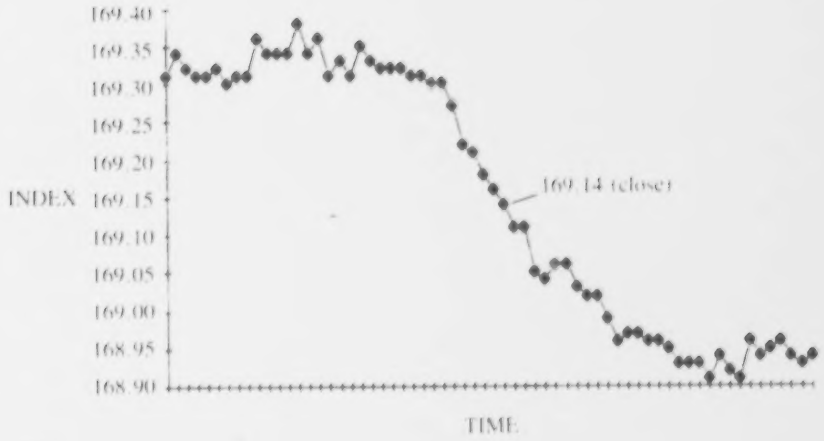
A4
S&P 500–821215



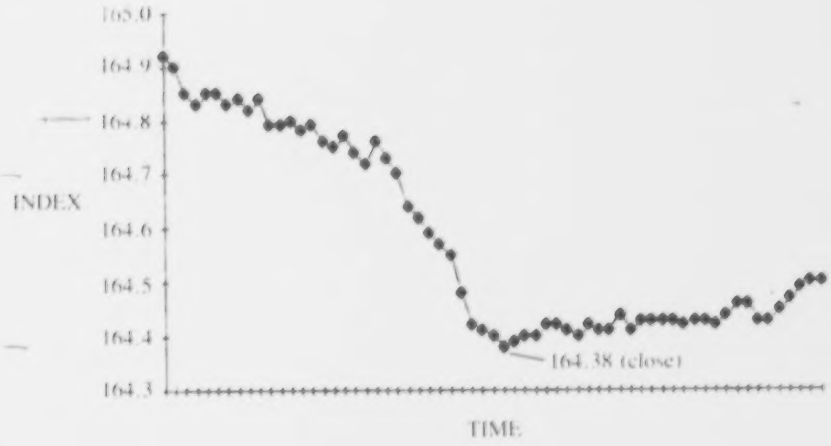
A5
S&P 500–830317



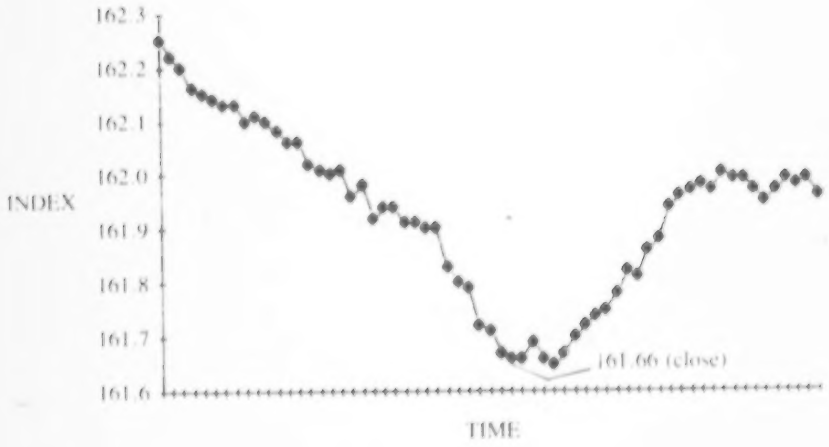
A6
S&P 500–830616



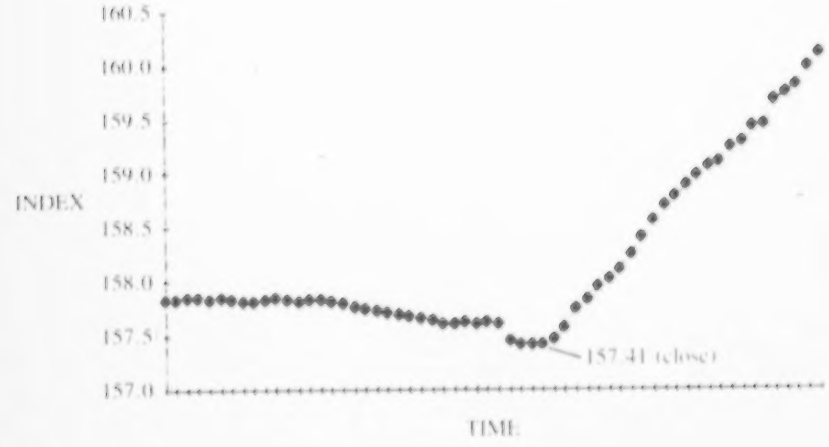
A7
S&P 500–830915



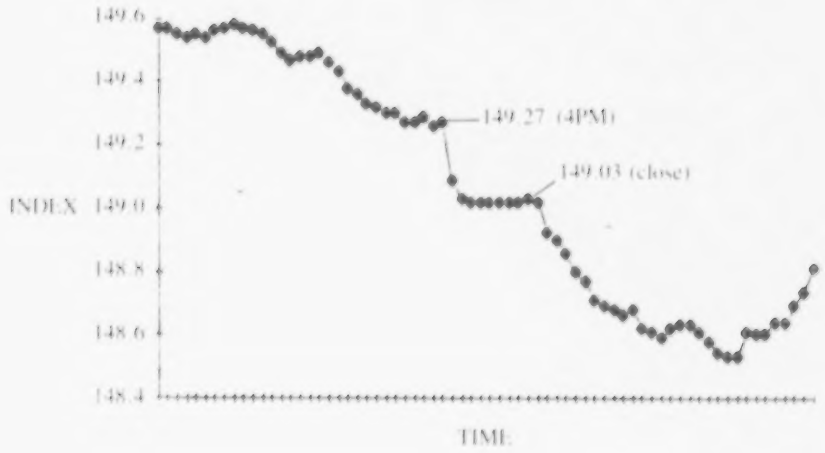
A8
S&P 500–831215



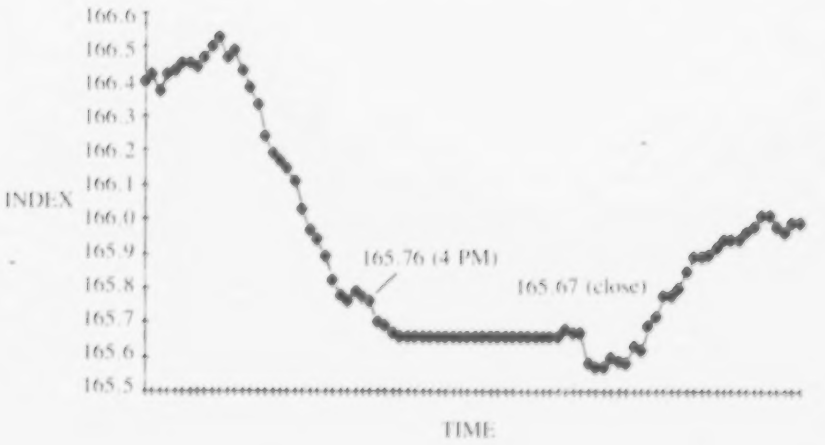
A9
S&P 500–840315



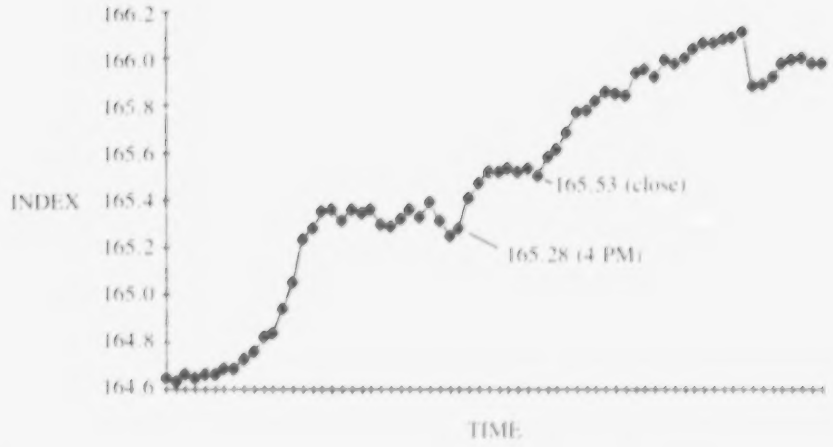
A10
S&P 500–840615



A11
S&P 500–840921



A12
S&P 500–841221



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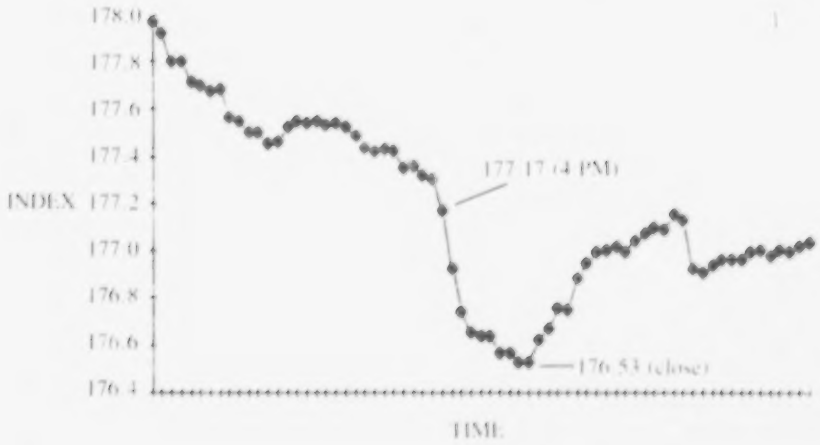
S&P 500–850315



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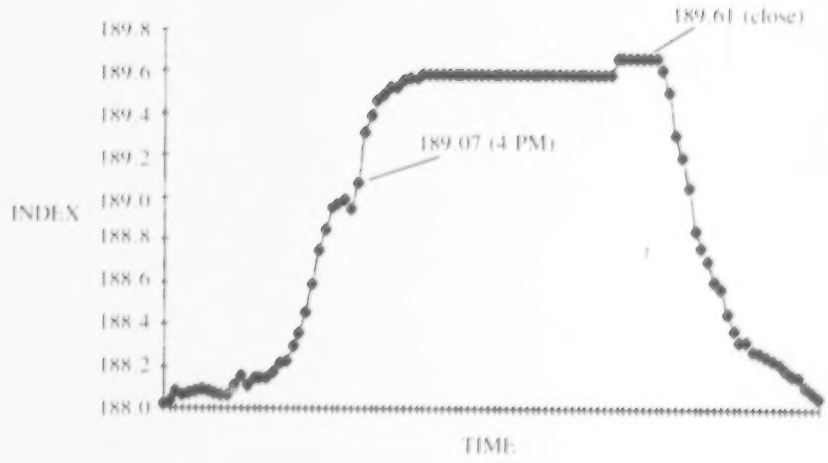

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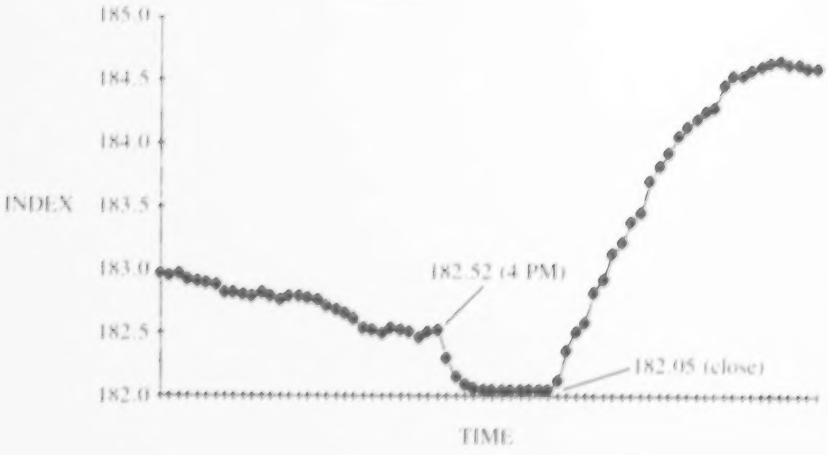

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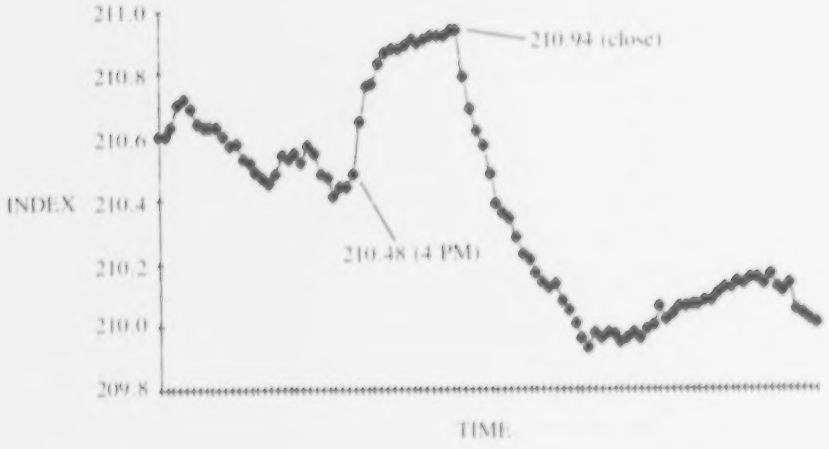

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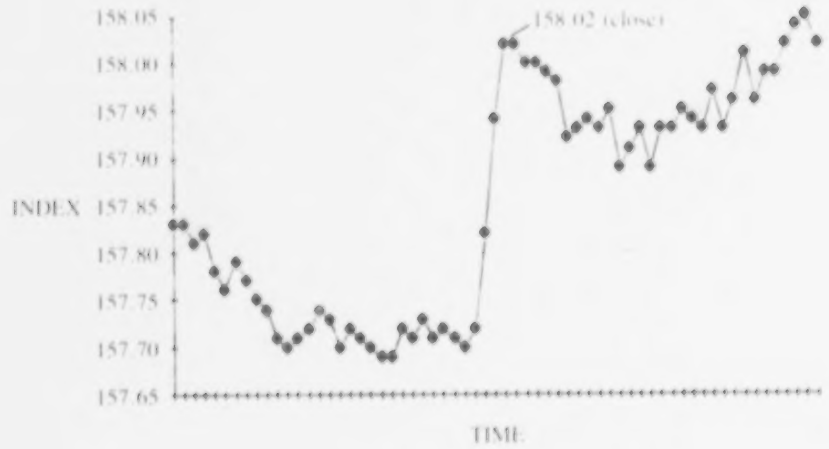

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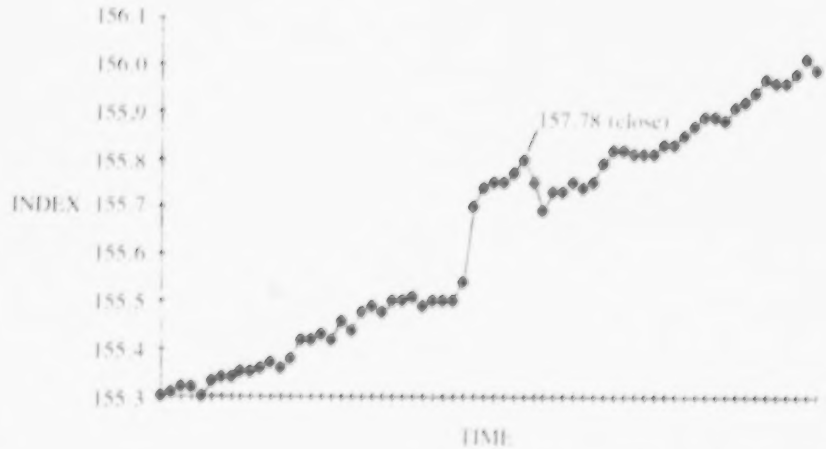

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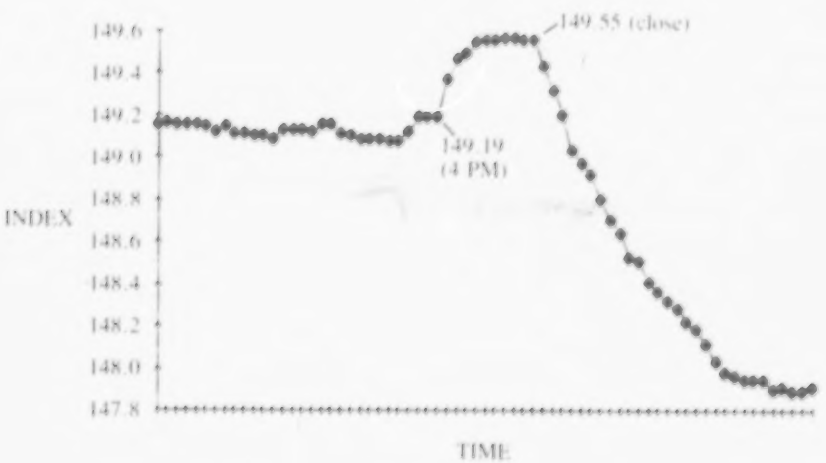

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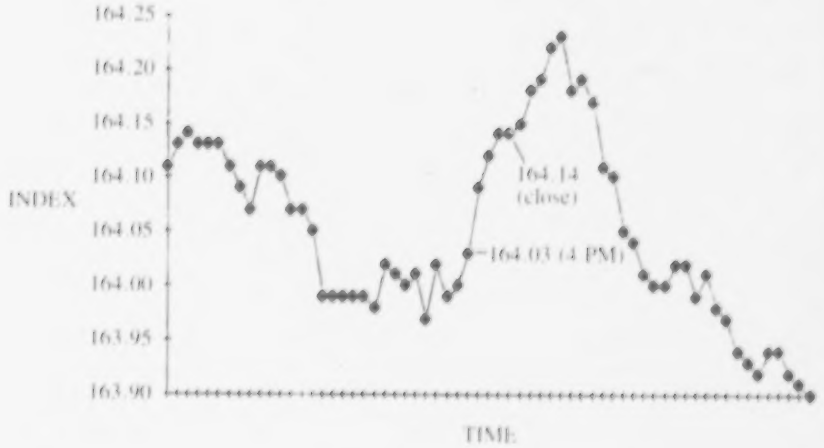

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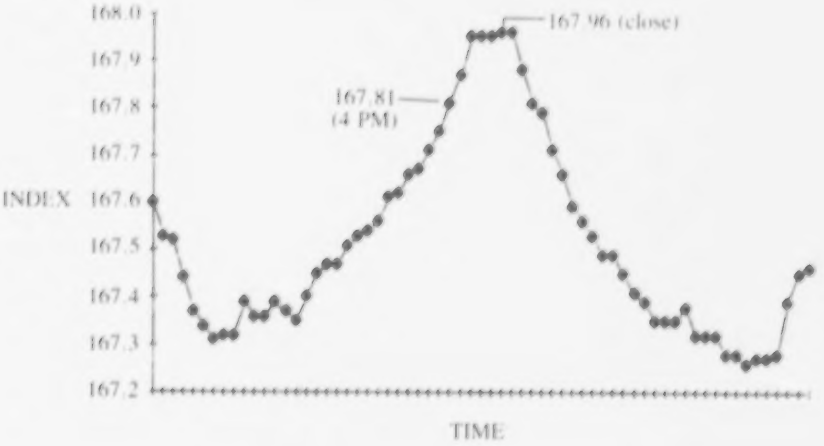

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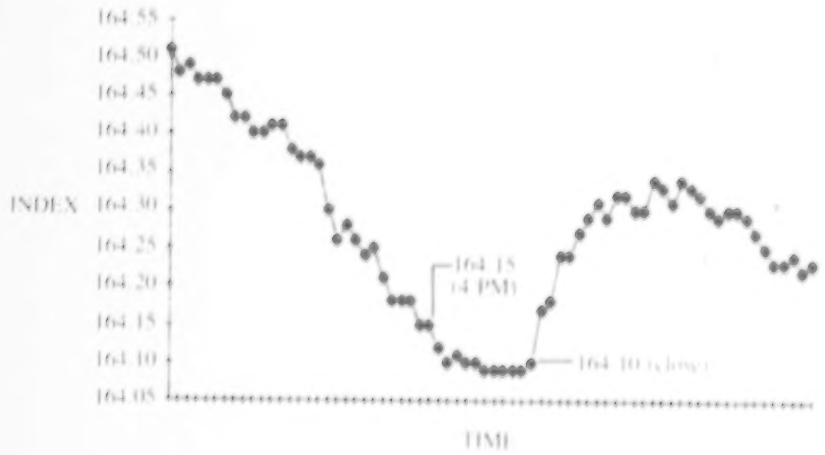

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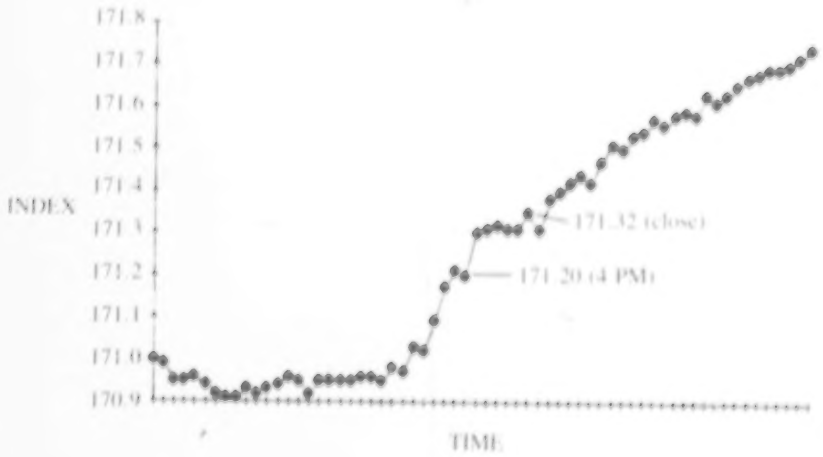

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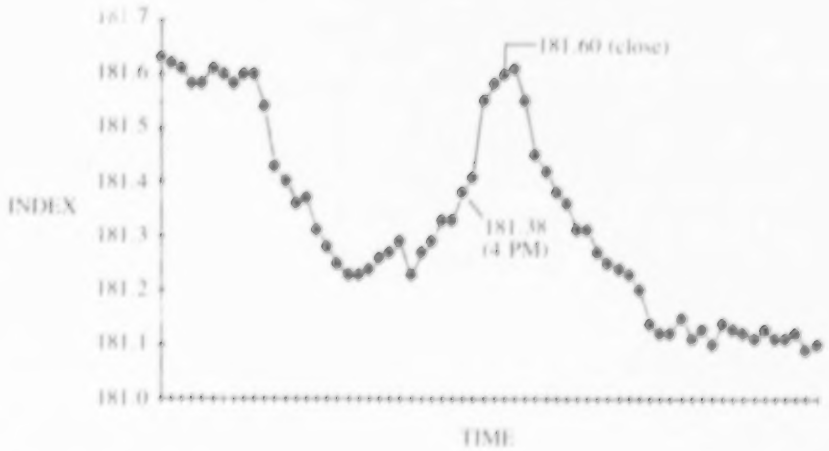

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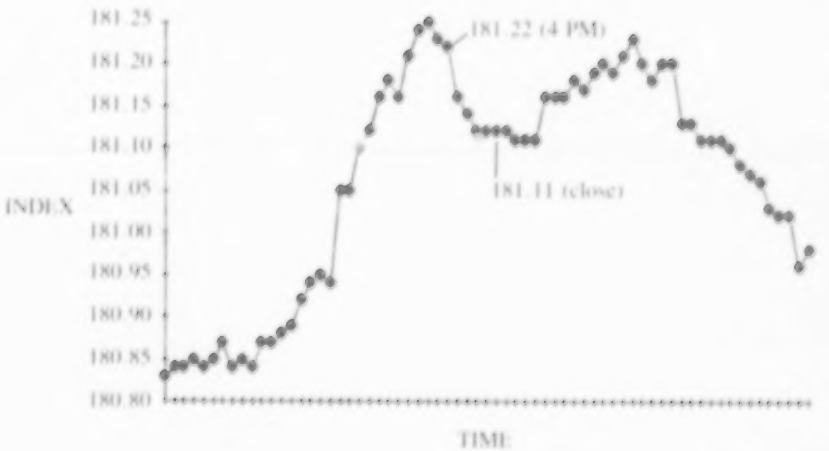

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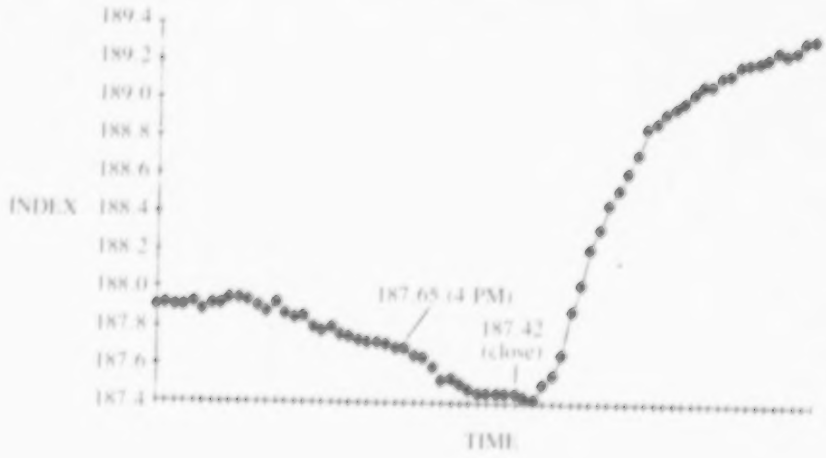

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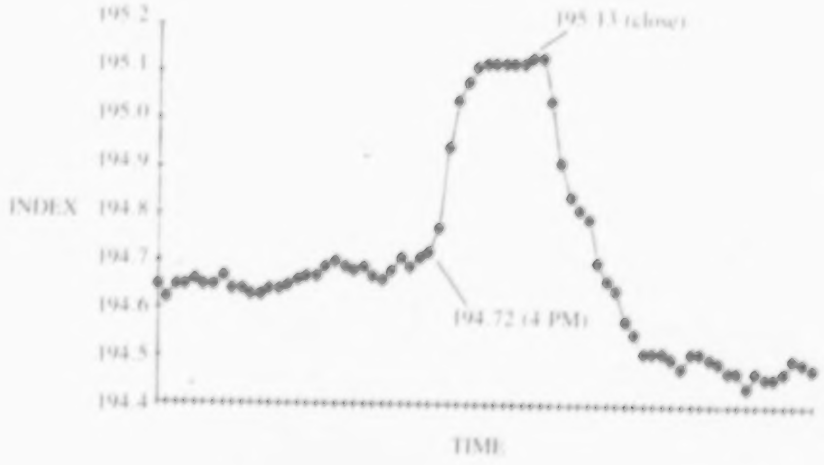

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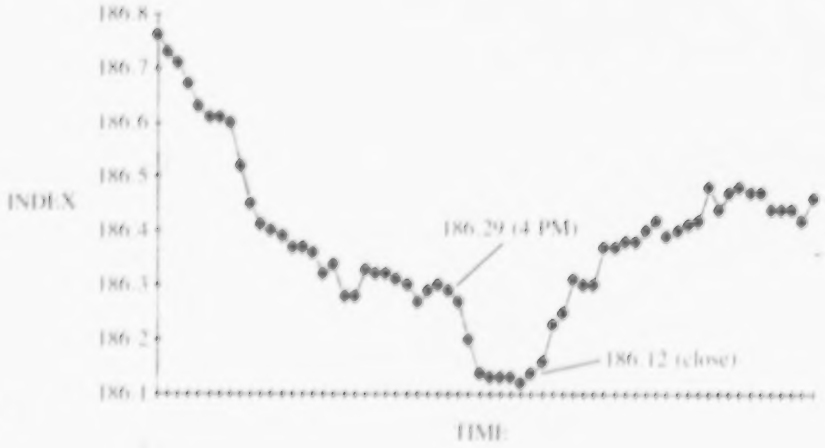

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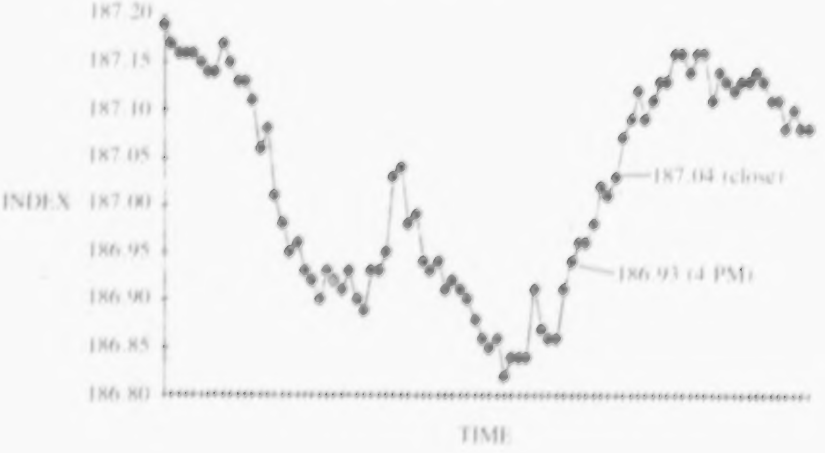

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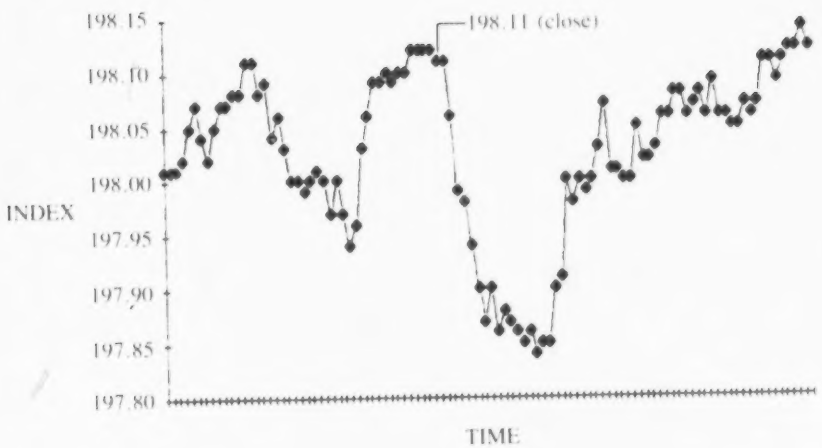

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